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NATIONAL DAM SAFETY PROGRAM. INDIAN HILLS DAM (MO 30075), MISSI--ETC(U)
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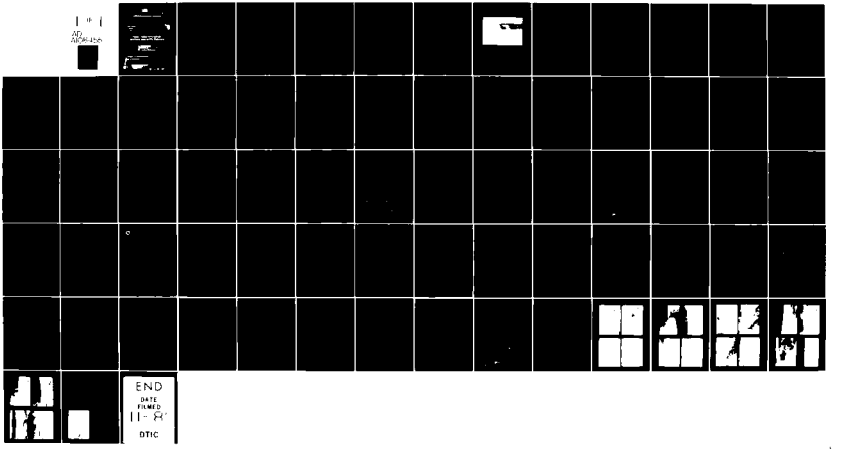

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.	

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Indian Hills Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Indian Hills Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classifed as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

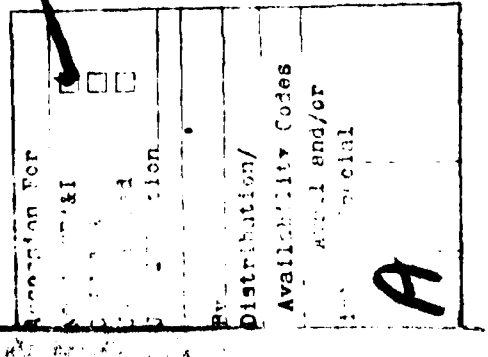
1) Spillway will not pass 50 percent of the Probable Maximum Flood
2) Overtopping could result in dam failure
3) Dam failure significantly increases the hazard to loss of life downstream

SUBMITTED BY: SIGNED
Chief, Engineering Division

21 MAR 1980
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

21 MAR 1980
Date



INDIAN HILLS DAM

CRAWFORD COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30075

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared by

Anderson Engineering, Inc. Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction of

St. Louis District, Corps of Engineers

For

Governor of Missouri

February, 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Indian Hills Dam
State Located:	Missouri
County Located:	Crawford County
Stream:	Brush Creek
Date of Inspection:	26 June 1979

Indian Hills Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately 15 miles downstream of the dam. Located within this zone are three road crossings, a bridge on Highway 19, a private campground and the city of Oak Hill (six dwellings). The dam is in the intermediate size classification, since it is greater than 40 ft. high but less than 100 ft. high, and the maximum storage capacity is greater than 1000 acre-ft. but less than 50,000 acre-ft.

Our inspection and evaluation indicates that the combined spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 16 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of

intermediate size with a high downstream hazard potential pass the PMF. The 100-year frequency flood will not overtop the dam. The 100-year flood is one that has a 1 percent chance of being equalled or exceeded in any given year.

Deficiencies visually observed by the inspection team were: (1) large seepage area at toe and lower 15 ft. of embankment between Stas. 2+00 and 6+00; (2) severe erosion of berm separating the primary spillway discharges from the downstream flood plain; (3) severe erosion of the berm separating the emergency spillway channel from the primary spillway pipe; (4) seepage and undermining under the emergency spillway slab; (5) apparent seepage on downstream face between Stas. 12+00 and 12+60; (6) apparent seepage at downstream toe between Stas. 9+50 and 11+00; (7) a small slough on the downstream face at Sta. 6+00; (8) numerous small erosion gullies along the downstream face; (9) scattered tree and brush growth with dense trees and brush on the downstream face near the west abutment; and (10) a deep erosion gully at the west downstream abutment-embankment contact. Another deficiency was the lack of seepage and stability analysis records.

It is recommended that the owners take the necessary action in the very near future to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

David Daniels
David Daniels, P.E.
Hanson Engineers, Inc.

Steven L. Brady, P.E.
Anderson Engineering, Inc.

Tom Beckley
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Anderson Engineering, Inc.

Nelson Morales, P.E.
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AERIAL VIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

INDIAN HILLS DAM - ID No. 30075

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Indian Hills Dam in Crawford County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Indian Hills Dam is an earth fill structure approximately 50 ft. high and 1300 ft. long at the crest. The appurtenant works consist of a primary spillway concrete riser (4.5' x 4.5') with a 36 in. diameter CMP tube outlet, a six in. diameter gate valve is included in the concrete riser structure for drawdown purposes. The emergency spillway in the right abutment is concrete lined. Sheet 3 of Appendix A shows a plan, profile and typical section of the embankment.

B. Location:

The dam is located in the Northwestern part of Crawford County, Missouri on Brush Creek. The dam and lake are with-

in the Cuba, Missouri 7.5 minute quadrangle sheet (Section 10, T39N, R5W - latitude 38° 06.5'; longitude 91° 27.5'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 50 ft. and a maximum storage capacity of approximately 7320 acre-ft., the dam is in the intermediate size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately 15 miles downstream of the dam. Located within the damage zone are three road crossings, a bridge on Highway 19, a private campground, and the city of Oak Hill (six dwellings).

E. Ownership:

The dam is owned by Indian Hills Property Owners Association, Inc. The owners' address is 17 Indian Hills Drive, Cuba, Missouri 65453.

F. Purpose of the Dam:

The dam was constructed primarily for lakeside community development.

G. Design and Construction History:

The development was planned by the American Realty Service Corporation, Memphis, Tennessee. This firm declared bankruptcy in 1975, and the receivership for the firm stated that no plans or other information for this dam were in the files. No additional design or construction data were found.

The dam was constructed in 1960 by Libhart Excavators of Cuba, Missouri. Contact was made with Mr. Don Libhart, 1009 Sycamore, Cuba, Missouri, (phone 314-885-7976) who with his father constructed the dam. The information contained in this paragraph was obtained from Mr. Don Libhart. The embankment was completed in 60 days in the summer of 1960. Excavation for the clay core started at the west abutment in the existing streambed. The core trench was approximately 30 ft. wide and varied in depth from 15 to 25 ft. The material for the clay core was obtained from the eastern part

of the lake bed. Construction of the dam continued from west to east with concurrent excavation and filling operations; this enabled construction of the embankment without diverting the stream flow by allowing the backup of water to occur as a section of the embankment was completed.

Riprap was placed on the upstream face of the embankment at the time of construction, and replacement and repair of the riprap has continued.

The primary spillway pipe near the east abutment was placed in the embankment, and the fill was hand-tamped. The pipe does not have any anti-seep collars.

H. Normal Operative Procedures:

Normal flows are passed through the inlet structure into a 36 in. diameter CMP with excess flow being carried by the emergency spillway on the east end of the dam. The water level can be lowered approximately seven ft. from normal pool by means of the six in. gate valve located in the inlet structure. The maximum high water level appears to have been at elevation 898.8. Mr. Ernie Cramer of the Association Board of Governors said the dam had never been overtopped.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet, is approximately 9714 acres.

B. Discharge at Dam Site:

(1) All discharge at the dam site is through uncontrolled spillways. Rating curves were developed assuming a combination of Weir and pipe flow for the principal spillway and critical flow for the emergency spillway section.

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 900.0 ft., MSL): 6331 cfs

(3) Estimated Capacity of Primary Spillway: 105 cfs

(4) Estimated Experienced Maximum Flood at Dam Site: Unknown - This year the high water mark was elevation 898.8 ft., MSL: 3926 cfs

(5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

(6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable

(7) Gated Spillway Capacity at Pool Elevation: Not Applicable

(8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

(1) Top of Dam: 900.0 ft., MSL (Low Point), 900.5 ft., MSL (High Point)

(2) Principal Spillway Crest: 894.8 ft., MSL

(3) Emergency Spillway Crest: 895.1 ft., MSL

(4) Principal Outlet Pipe Invert: 880.4 ft., MSL

(5) Streambed at Centerline of Dam: 850.5 ft., MSL

(6) Pool on Date of Inspection: 894.56 ft., MSL

(7) Apparent High Water Mark: 898.8 ft., MSL

(8) Maximum Tailwater: Unknown

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 14,400 ft.

(2) At Principal Spillway Crest: 13,000 ft.

(3) At Emergency Spillway Crest: 13,100 ft.

E. Storage Capacities:

(1) At Principal Spillway Crest: 5300 Acre-ft.

(2) At Top of Dam: 7320 Acre-ft.

(3) At Emergency Spillway Crest: 5400 Acre-ft.

F. Reservoir Surface Areas:

(1) At Principal Spillway Crest: 355 Acres

(2) At Top of Dam: 422 Acres

(3) At Emergency Spillway Crest: 359 Acres

G. Dam:

(1) Type: Rolled Earth

(2) Length at Crest: 1300 ft.

(3) Height: 50 ft.

(4) Top Width: 26 ft. with 22 ft. asphalt paved road

(5) Side Slopes: Upstream slope to water edge 5.2H:IV; Downstream 2.5H:IV and 3.5H:IV.

(6) Zoning: Unknown but according to the contractor is homogeneous.

(7) Impervious Core: Unknown

(8) Cutoff: According to Mr. Don Libhart, the contractor, a core trench approximately 30 ft. wide and 15 to 25 ft. deep was constructed and filled with compacted clay from the lake area.

(9) Grout Curtain: Unknown

H. Diversion and Regulating Tunnel:

(1) Type: None

(2) Length: None

(3) Closure: None

(4) Access: None

(5) Regulating Facilities: None

I. Spillway:

I.1 Principal Spillway:

(1) Location: East end of dam at Sta. 14+15

(2) Type: 4.5 ft. x 4.5 ft. concrete drop inlet structure with a 36 in. CMP outlet through the embankment.

I.2 Emergency Spillway:

(1) Location: East abutment

(2) Type: Concrete control section and bedrock spillway.

I. Regulating Outlets:

A six in. diameter valve located at the inlet structure (Sta. 14+15) is used for lowering the water level approximately seven ft. from normal pool level. The flow through the gate valve is discharged through the 36 in. diameter CMP primary spillway pipe.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

The plans for the dam were furnished the contractor by the American Realty Service Corporation. Mr. Don Libhart, the contractor, recalls a set of plans being used during construction, however plans have not been found. The agency or firm responsible for the preparation of the plans has not been determined to date. No documentation or construction inspection records has been obtained. To our knowledge, there are no documented maintenance and operation data.

A number of inspections have been made by the Missouri Geological Survey and Water Resources, Rolla, Missouri, (requested by the homeowners association). Their reports are included in Appendix A.

A. Surveys:

No information regarding pre-construction surveys was able to be obtained. The top of a steel post at the southwest corner of the emergency spillway was used as datum for site survey (elevation 100.0 as shown on Sheet 3 of Appendix A). It was estimated from quad sheets and photographs that this elevation approximately corresponds to mean sea level (MSL) elevation 902.3.

B. Geology and Subsurface Materials:

The site is located in the north central portion of the Ozarks geologic region of Missouri. The Ozarks are charterized topographically by hills, plateaus and deep valleys. The most common rock types are dolomite, sandstone & chert.

The bedrock near the dam site consists of fine grained, silty, cherty dolomite with oolitic chert. This bedrock represents the upper part of the Canadian Series of the Ordovician System. The publication "Caves of Missouri" lists a total of seven caves known to exist in Crawford County. All but one of these caves are clustered in a nine square mile area about 12 miles southeast of the site. The other cave is located about 17 miles east of the dam site.

The "Geologic Map of Missouri" indicates a normal fault passing near the site in a northwest-southeast direction. The Missouri Geological Survey has indicated that the faults

in this area are generally considered to be inactive and have been for several hundred million years (rock associated with the Ordovician Period - 500 million years old).

Soils in the area of the dam site appear to be primarily thin deposits of residual silty clays with rock fragments. The soils are of the Lebanon-Nixa-Clarksville Association and have developed from thin loessial soils deposited over weathered material from cherty dolomites. The loessial thickness map indicates that upland areas may have between 2.5 and 5.0 ft. of loess cover.

C. Foundation and Embankment Design:

No information on the foundation and embankment design could be obtained. There is apparently no particular zoning of the embankment, and no internal drainage features are known to exist. No construction inspection test results are available.

D. Hydrology and Hydraulics:

No hydraulic and hydrologic design data were available. Based on a field check of spillway dimensions, embankment elevations and a check of the drainage area on U.S.G.S. quad sheets, hydraulic analyses using U.S. Army Corps of Engineers guidelines were performed and appear in Appendix C. It was concluded that the structure will pass 16 percent of the Probable Maximum Flood without overtopping. The 100-year frequency flood will not overtop the dam.

E. Structure:

The primary spillway consists of (1) a concrete inlet structure (within the lake area) with a six in. gate valve used to lower the lake level a maximum of seven ft. below normal pool, and (2) a 36 in. CMP tube from the inlet structure to the downstream discharge channel. The flow in the 36 in. CMP is uncontrolled. No anti-seep collars were installed on the pipe. The concrete in the inlet structure appeared in good condition. The emergency spillway has a concrete lining, and the concrete was in fairly good condition. No design details were available for either structure.

2.2 CONSTRUCTION:

No construction inspection data were available.

2.3 OPERATION:

No operation and maintenance records were available. Inspection indicates that maintenance of the dam (mowing the grass and removing brush) is done on a regular basis. According to Mr. Ernie Cramer of the property owners Board of Governors, the Association requests an annual inspection of the dam from the Missouri Geological Survey and Water Resources. Copies of these reports are included in Appendix A. Limited funding has been provided by the Association to accomplish the recommendations of the inspection reports. The lake is normally lowered seven ft. every two years; at that time, the growth on the shoreline is chemically treated to remove weed growth, riprap is repaired and replaced, and siltation is removed from the cove areas.

2.4 EVALUATION:

A. Availability:

The engineering data available are as listed in Section 2.1.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on 26 June 1979. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Tom Beckley P.E.- Anderson Engineering, Inc. (Civil Engineer)
Steve Brady P.E.- Anderson Engineering, Inc. (Civil Engineer)
Nelson Morales P.E.- Hanson Engineers, Inc. (Hydrologic and Hydraulic Engineer)
David Daniels P.E. - Hanson Engineers, Inc. (Geotechnical Engineer)

B. Dam:

The embankment of the dam appears to be in generally good condition. No surface cracking or unusal movement was obvious. The dam is level across the top and is straight except for a slight curve at the west end. A small slough was visible 15 ft. down from the crest on the downstream face at Sta. 6+00. Numerous small erosion gullies were present along the downstream face of the dam. These gullies varied in depth from three to six inches.

The embankment is grass coverd and appears to be mowed regularly. Scattered trees and brush are starting to grow on the downstream face and near the toe.

Relatively dense growth of trees and brush were present at and beyond the toe from the west abutment to Sta. 6+00. At the junction of the west abutment and downstream embankment, an erosion gully was observed, varying in depth to four ft. and width to five ft.

No animal burrows were detected, although some could exist in the areas of heavier brush and grass growth.

Riprap was present on the front face of the embankment. At some areas of the embankment the riprap was very scattered, although no serious erosion appears to have occurred.

An extremely wet and soft area existed on the downstream face of the dam from Sta. 2+00 to Sta. 6+00. This area extended from the toe to about 15 ft. up the embankment. A significant flow of water was noted, with large ponds of water immediately downstream from the toe. An additional damp area was noted on the embankment at about elevation 890.8 between Sta. 12+00 and 12+60. This area had a growth of reeds. No noticeable flow could be detected although some seepage was evidently present. Near the toe of the embankment between Sta. 9+50 to 11+00, a damp area existed in a grove of small trees. No movement of water was detected.

No instrumentation (monuments, piezometers, etc.) was observed.

A later flight over the lake showed that some work had been done on the downstream toe and the lower portion of the embankment. Photo No. 21 in Appendix D shows the area being worked on. Mr. Ernie Cramer said the lower portion of the embankment had been graded, trees had been cleared from the embankment, and the marshy area beyond the downstream toe had been cleared and graded to drain.

C. Appurtenant Structures:

C.1 Primary Spillway:

The primary spillway consists of a concrete riser, with trash rack and a six in. diameter gate valve, about 15 ft. from the shoreline near the east abutment. The riser and associated components appeared to be in good condition. The inlet structure was relatively clear of debris. The outlet from the riser is a 36 in. diameter CMP through the dam, extending 285 ft. downstream from the riser. Severe erosion of the berm separating the outlet area from the downstream floodplain has occurred. The flow of the spillway releases is channelized toward this berm by the rock ledges in the emergency spillway. The top of the spillway pipe is exposed from near the northeast crest of the dam to the end of the pipe. Seepage around the pipe was not observed, although this condition has been mentioned in previous reports.

C.2 Emergency Spillway:

The emergency spillway is a trapezoidal concrete-lined channel. The concrete appears to be in fairly good condition. The approach channel is relatively clear, with some

small brush growth. On either side of the roadway through the spillway, steel posts with a connecting cable strung between the posts were present. This system would tend to inhibit passage of debris through the spillway. A later visit to the site found that these posts had been removed. The discharge from the spillway is down the right abutment; this channel has some small brush growth in it. Undermining of the concrete slab has occurred in some areas, and seepage was observed under the emergency spillway slab. The bottom of the upper portion of the discharge channel is bedrock and slopes to the west (toward the primary spillway). Discharge from the emergency spillway is directed by the sloping rock toward the earth embankment separating the emergency and primary spillways. This is causing severe erosion on the west side of the channel, which could eventually undermine the support for the end of the primary discharge pipe.

D. Reservoir:

The watershed area varies from residential development near the lake to farmland and pasture land. The slopes adjacent to the lake are moderate, and no sloughing or serious erosion was noted. As was noted in a previous report by the Missouri Geological Survey (see Appendix A), there appears to be a problem with excessive siltation in the upper reaches of the lake.

E. Downstream Channel:

The downstream channel has eroded down to solid bedrock. Some small tree and brush growth is also present. The flow is eroding away the west berm of the channel largely because the bedrock surface slopes to the west.

3.2 EVALUATION:

If left uncontrolled, the existing seepage area between Stas. 2+00 and 6+00 and the marshy condition in the floodplain below, may adversely affect the stability of the dam. The two areas of possible seepage should be checked. All of the seepage areas should be checked by an engineer experienced in the design and construction of dams. Remedial measures will be required. The stream channel immediately adjoining the dam is overgrown with brush, cattails, and ponded water; this weakens the floodplain foundation immediately adjoining the dam. The trees and heavy brush near the west abutment are a potential seepage hazard and encourage animal burrows. The erosion resistance of the west abutment down-

stream contact is inadequate. The erosion gullies on the downstream face and the one slough area will continue to deteriorate if they are not repaired. The erosion of the berm separating the primary spillway outlet and downstream floodplain is serious and if not controlled the berm will be breached and allow water to flow across the floodplain near the toe of the dam. If undermining of the emergency spillway lining continues, then the lining could fail. The erosion of the berm separating the emergency spillway and the primary spillway outlet is serious and if it is not controlled the support of the outlet pipe could be undermined.

Photographs of the dam, appurtenment structures, the reservoirs, and the watershed are presented in Appendix D.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no controlled outlet works for this dam, except for the six in. diameter gate valve at the inlet structure. The gate valve is used for lowering the water level to about seven ft. below normal pool elevation. The spillway is uncontrolled, so that the pool is normally affected by rainfall, runoff, evaporation, seepage, and the capacities of the uncontrolled spillways.

4.2 MAINTENANCE OF DAM:

The property owners association is providing funding for maintenance of the dam; based upon the inspection reports provided them (see Appendix A), they select maintenance priorities based on available funding.

The lake is normally lowered every two years. At that time, the sediment in the cove areas is removed and the shoreline is inspected and repaired, if needed. Additional riprap has been placed on the upstream face of the embankment each time the lake has been lowered. The asphalt roadway surface on the crest of the dam was sealed in 1978. Mowing of the embankments is done on an as-needed basis.

Subsequent to the inspection of the dam, the Association has commenced repair procedures on the reported wet area near the west abutment. Scheduled for completion this year is the removal of the tree growth, drainage of the ponding areas and placement of the seepage control layer, as recommended by Dr. Williams in his geologic report of October 31, 1978. Completion of the berm is planned for 1980. The Association plans to continue the berm the full length of the embankment.

Water which was previously ponding near the east end of the dam was eliminated in 1978 by grading the downstream floodplain to provide drainage from the area.

4.3 MAINTENANCE OF OPERATING FACILITIES:

The gate valve and associated components appear to be in good condition. The gate valve is normally used to lower the lake level every two years. Regularly scheduled maintenance is not planned but used on an as-needed basis.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The Association is attempting to maintain the dam in an acceptable manner. As tree and brush growth develop, they should be removed on a yearly basis. The erosional areas at the west abutment-embankment contact and at the downstream channel should be corrected and maintained. Seepage areas, as noted, should be corrected. Correction of these items should be done under the guidance of a professional engineer experienced in the design and construction of earthen embankments.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. & B. Design and Experience Data:

The hydraulic and hydrologic analyses were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) an estimate of the pool and drainage areas from the U.S.G.S. quad sheet; and (3) experience data. Our hydrologic and hydraulic analyses using U.S. Army Corps of Engineers guidelines appears in Appendix C.

C. Visual Observations:

The spillway should remain free of any obstructions. The downstream channel of the spillways should be kept clear of tree and brush growth. The discharge from the primary spillway pipe should be diverted away form the berm to prevent additional erosion of the berm. If discharge is not diverted then erosion will continue, causing complete removal of the berm and thereby allowing the spillway discharge to flow into the downstream floodplain near the toe of the dam. Some seepage was observed under the concrete lining of the emergency spillway. Continual discharge of the emergency spillway could erode the berm separating it from the end of the primary spillway.

D. Overtopping Potential:

Based on the hydrologic and hydraulic analysis presented in Appendix C, the combined spillways will pass 16 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief Engineers, require that this structure (intermediate size with high downstream hazard potential) pass the PMF, without overtopping. The structure will pass a 100-year frequency flood without overtopping.

The routing of the PMF through the spillways and dam indicates that the dam will be overtopped by 5.17 ft. at elevation 905.17. The duration of the overtopping will be 8.50 hours, and the maximum outflow will be 68,300 cfs. The

maximum discharge capacity of the spillways is 6331 cfs. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

No design and construction data were obtained for this dam. Mr. Don Libhart, the contractor, recalls a set of plans being used during construction, however no plans have been found. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

Grading of the downstream floodplain near the east end to eliminate ponding in that area and placement of additional riprap on the upstream face of the embankment have been accomplished. Also Mr. Cramer indicated that trees on the embankment have been removed and that the lower part of the embankment and the floodplain below the toe have been graded to drain.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in good condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) large seepage area at toe and lower 15 ft. of embankment between Stas. 2+00 and 6+00; (2) severe erosion of berm separating the primary spillway discharges from the downstream floodplain; (3) severe erosion of the berm separating the emergency spillway channel from the primary spillway pipe; (4) seepage and undermining under the emergency spillway slab; (5) apparent seepage on downstream face between Stas. 12+00 and 12+60; (6) apparent seepage at downstream toe between Stas. 9+50 and 11+00; (7) a small slough on the downstream face at Sta. 6+00; (8) numerous small erosion gullies along the downstream face; (9) scattered tree and brush growth with dense trees and brush on the downstream face near the west abutment; and (10) a deep erosion gully at the west downstream abutment-embankment contact. Another deficiency was the lack of seepage and stability analysis records.

The dam will be overtopped by flows in excess of 16 percent of the Probable Maximum Flood. The projected height (5.17') of overtopping for such a long period of time (8.5 hours) on an earthen embankment could cause serious erosion and could possibly lead to a failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on review of the information listed in Section 2.1, the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended

Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will continue to deteriorate and possibly could become serious in the future. The items recommended in paragraph 7.2A should be pursued without undue delay.

D. Necessity for Phase II:

Based on the result of the Phase I inspection, no Phase II inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

(1) Spillway size and/or height of dam should be increased to pass the PMF without undue delay. In either case, the spillway should be protected to prevent erosion.

B. O & M Procedures:

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams.

(2) Seepage in the areas between Stas. 2+00 and 6+00 and near Sta. 10+00 and 12+00 should be stopped or controlled to allow drainage and pressure relief in a safe manner. Seepage control works should be based on appropriate seepage analysis. The wet, marshy area in the floodplain below Stas. 2+00 through 6+00 should be cleaned out and drained to reduce wetness.

(3) The discharge from the primary spillway outlet should be directed away from the berm on its west side, or the berm should be restored and protected from future erosion.

(4) Discharge from the emergency spillway should be prevented from eroding the berm between it and the primary spillway pipe. With continued erosion, support for the primary spillway could be removed and the pipe damaged.

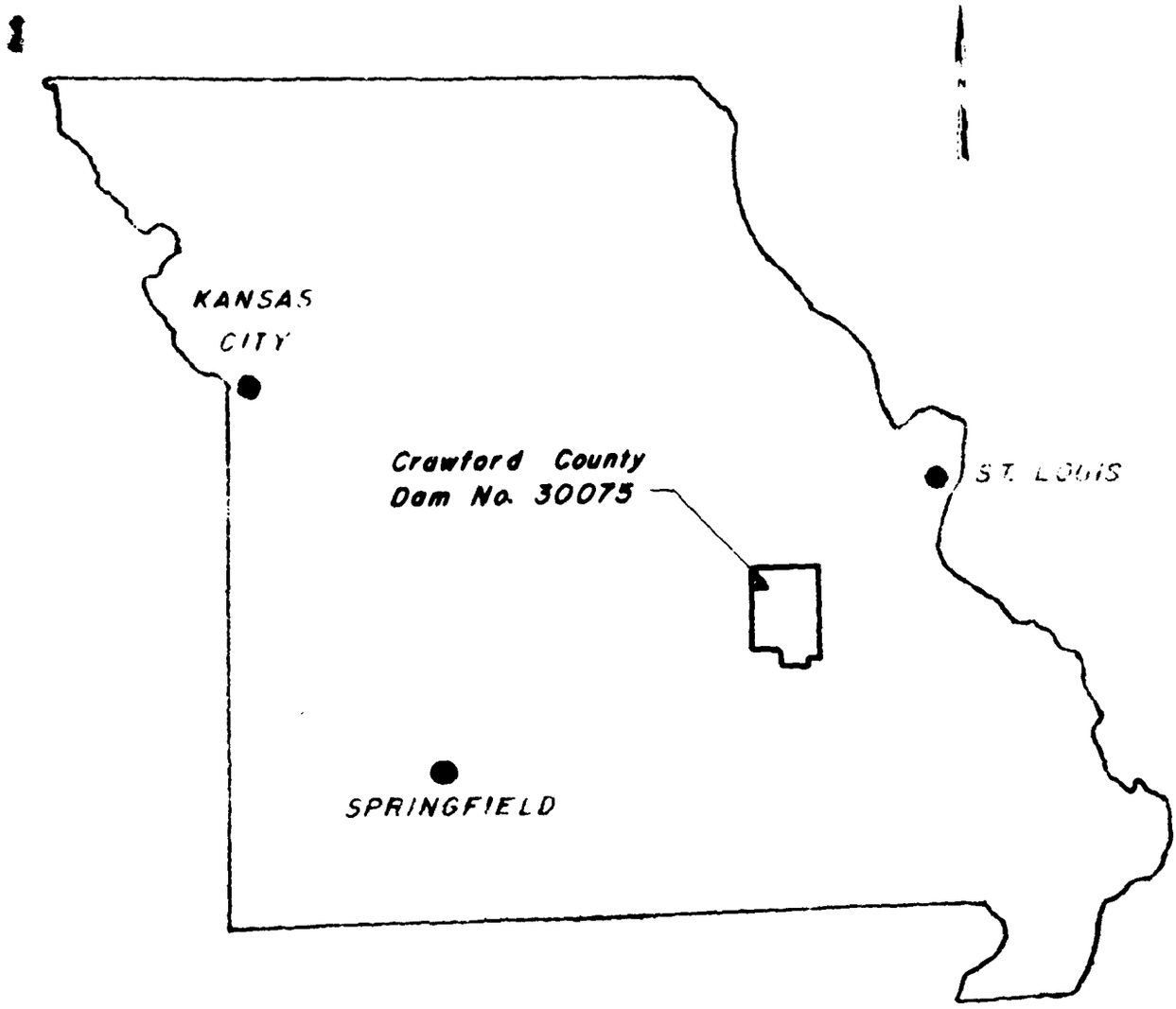
(5) Seepage under the emergency spillway concrete lining should be stopped to prevent further undermining and possible failure.

(6) Erosional areas and sloughs as previously described should be repaired and maintained.

(7) Brush and tree growth should be removed from the dam. This should be done under the guidance of a professional engineer experienced in the design and construction of dams. Indiscriminate clearing methods could jeopardize the safety of the dam. Brush and tree growth should then be removed from the dam on an annual basis.

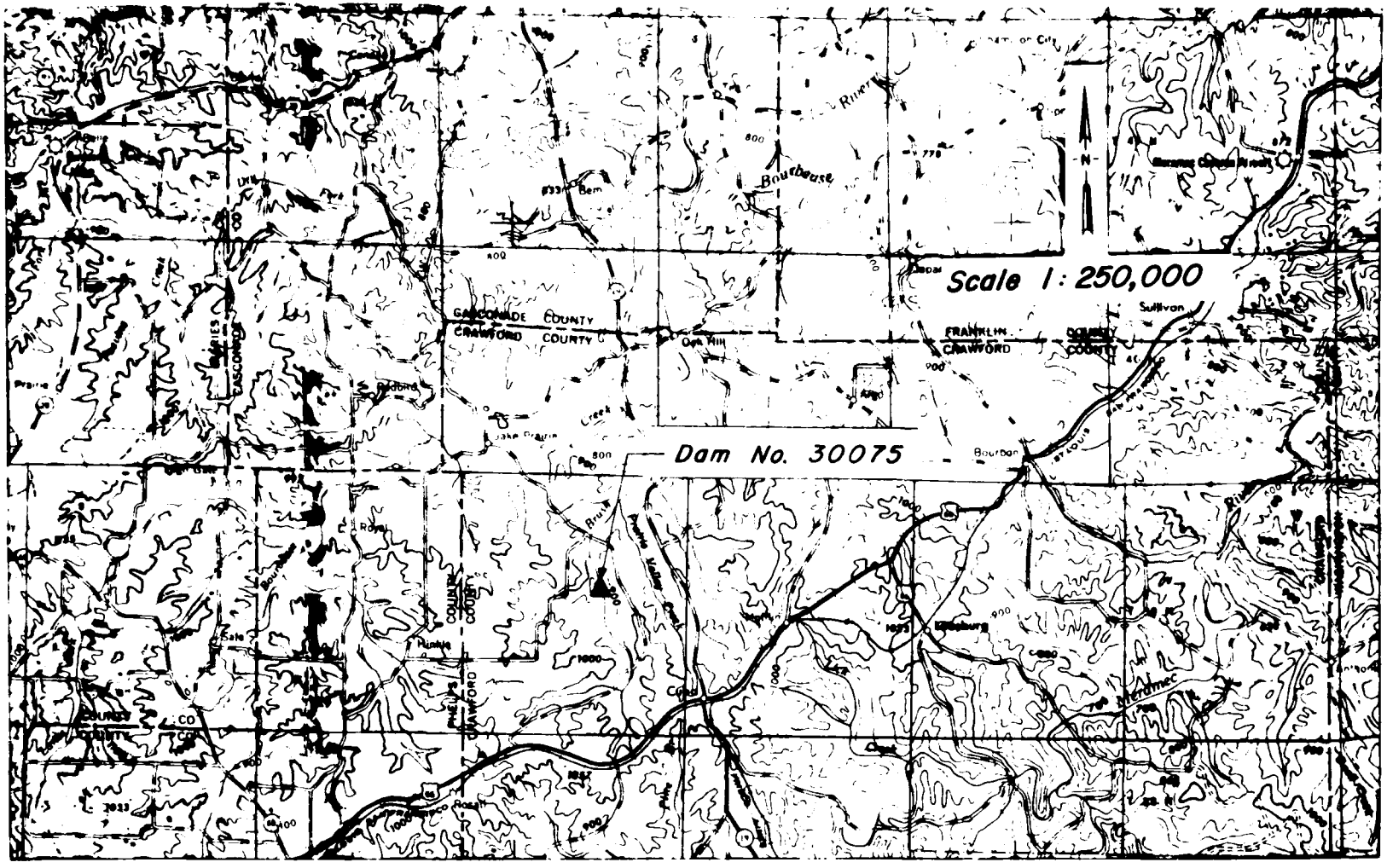
(8) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A



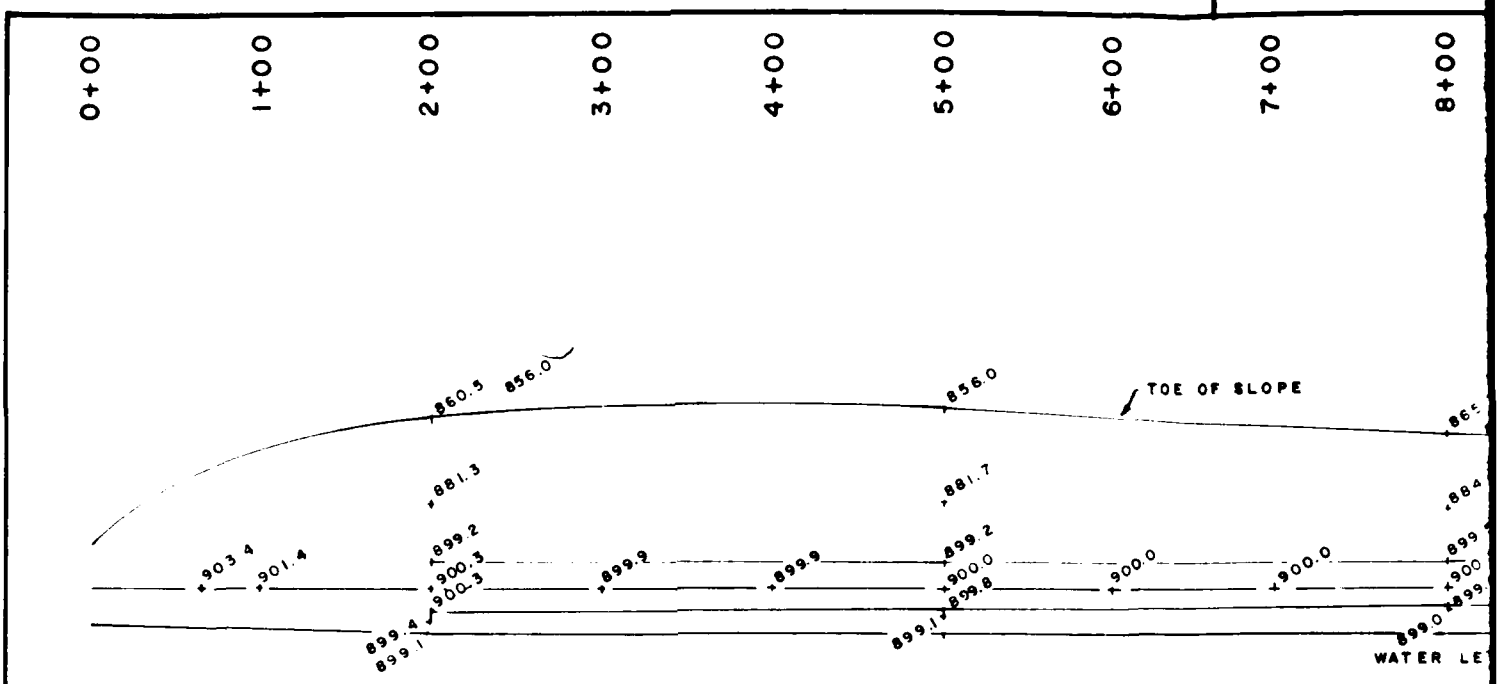
LOCATION MAP

SHEET 1 OF APPENDIX A



SITE VICINITY MAP

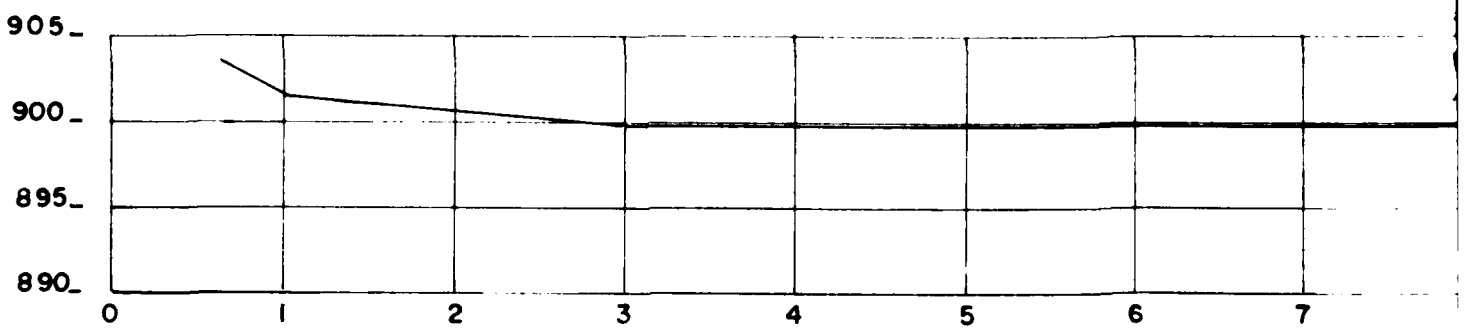
Sheet 2 Appendix A



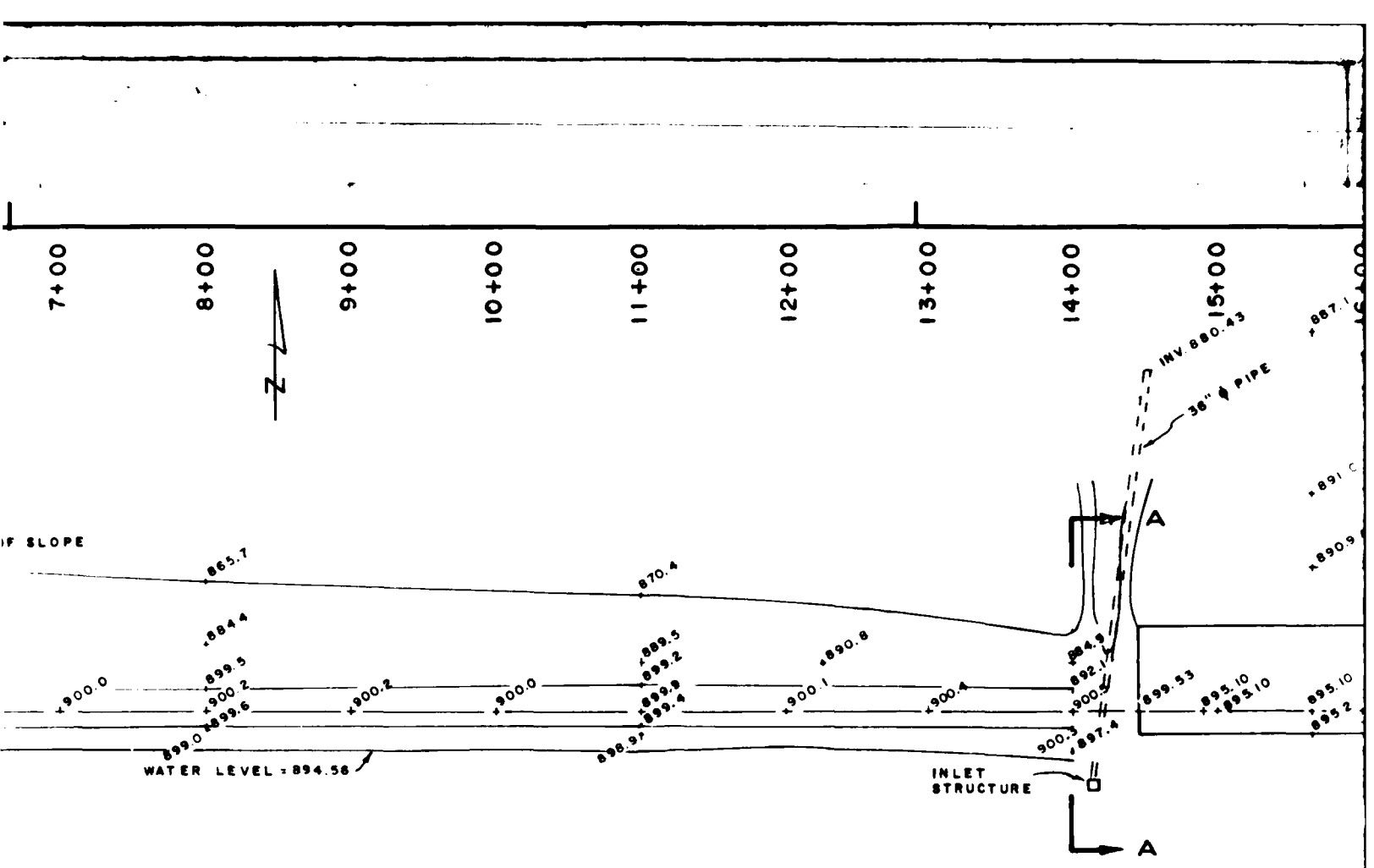
LAKE

BENCHMARK:
TOP STEEL POST AT SW CORNER
OF CONCRETE EMERGENCY
SPILLWAY AT EAST END OF DAM.
ELEV. = 902.30 M S L

PLAN VIEW
SCALE: 1" = 100'



PRO



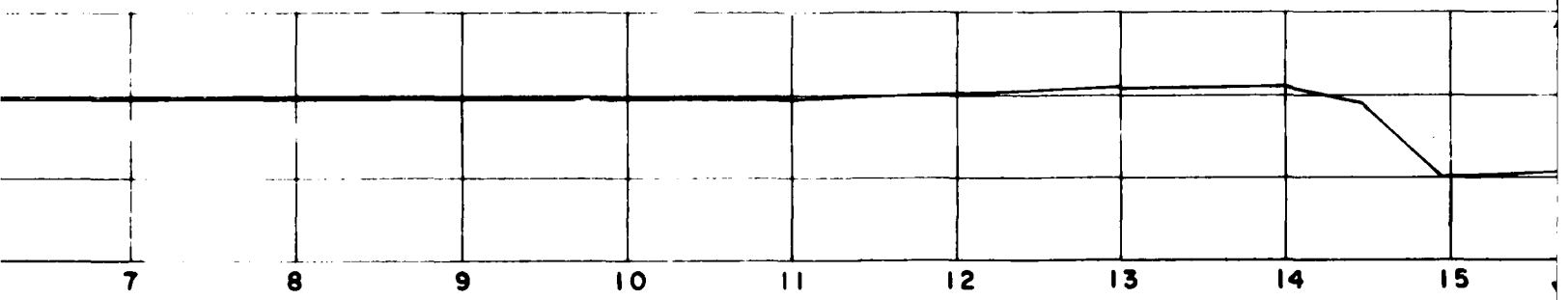
L A K E

AN VIEW

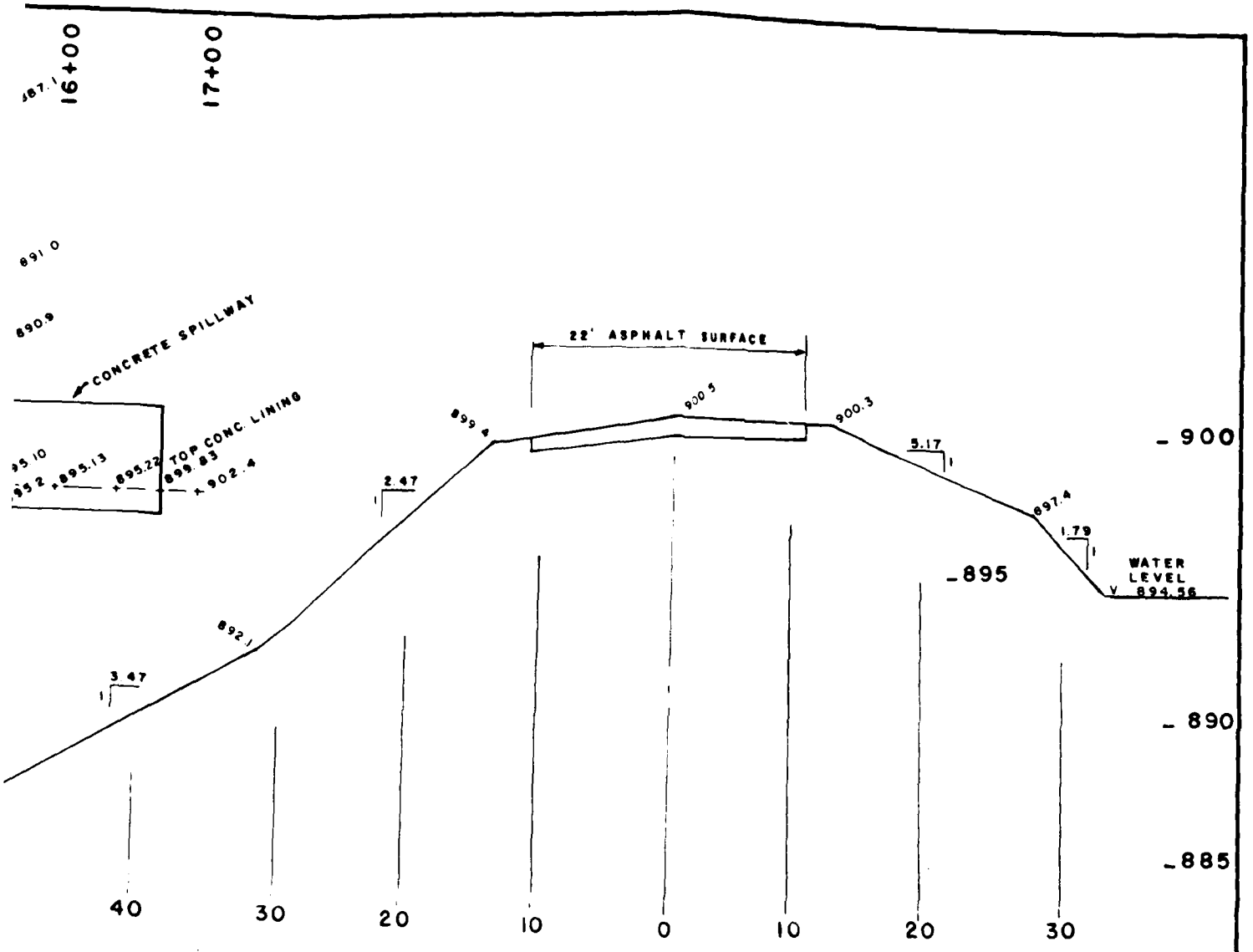
CALE 1" = 100'

884.9

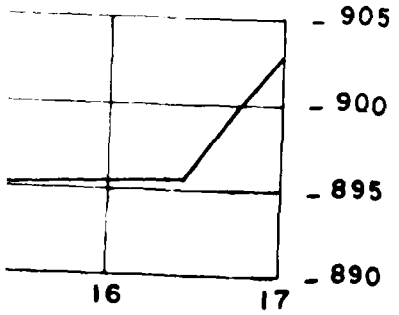
50



PROFILE



SECTION A-A STA 14+00



Sheet 3 Appendix A

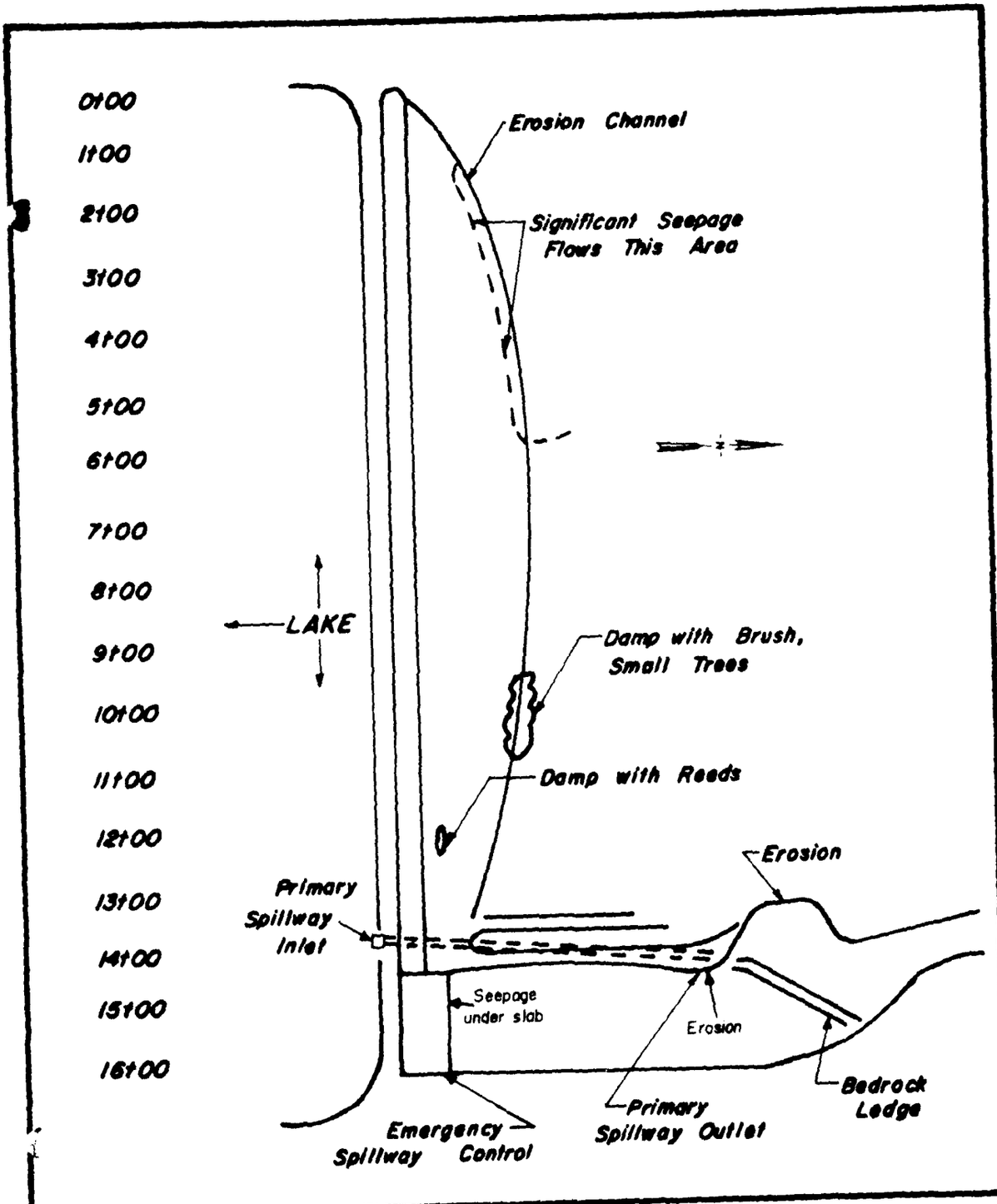
ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

INDIAN HILLS DAM

MO. No. 30075

PLAN & PROFILE

CRAWFORD COUNTY, MO.



DRAWN DER CHECKED DED DATE 1-23-79 JOB NO 79511	HANSON ENGINEERS SPRINGFIELD ILL PEORIA ILL	Plan Sketch Inspection Observations Sheet 4 Appendix A

BB #17

ENGINEERING GEOLOGIC REPORT OF THE INDIAN HILLS DAM

CRAWFORD COUNTY, MISSOURI

LOCATION: With the dam near the north section line of Sec. 15 on Brush Creek, T. 39 N., R. 5 W., Cuba Quadrangle.

At the request of Mr. Walter Erment, Indian Hills Property Association, an examination was made of the dam on 27 October 1978 to determine if any obvious defects exist that would require attention. Before discussing maintenance needs as observed during the field inspection, it is appropriate as well as a pleasure to commend the Indian Hills Property Association for developing a maintenance program and funding to support that program. During the present National Dam Inventory and Inspection Program, one of the most common problems that we have seen in reviewing these reports is the lack of care or interest in dam maintenance. As a result, numerous serious defects and deficiencies have developed in what were originally safe and sound dams. This is not the case for Indian Hills, in part due to the interest in maintenance and in part due to the capable people such as Mr. Cranmer who has both a definite interest and knowledge in how a dam should be maintained.

The previous reports on Indian Hills have noted the problem of seepage at the downstream toe on the western end of the dam. This seepage has increased to some extent through the years. It now persists as sustained flow. The lowermost 15 feet of the dam is also moist and somewhat soft. This soft zone has a lateral extent (length) of about 200 feet from the western valley slope extending toward the east to a point where the vigorous growth of fescue ceases to exist. This is a rather common occurrance on dams which do not have internal drainage facilities. It is important that this seepage and softness be attended to now. If allowed to continue, seepage will continue to soften and weaken the lower toe of the dam.

A suggested procedure to stabilize the toe and control seepage is the construction of a gravel berm on the downstream slope of the dam. An attached sketch outlines the approximate configuration such a berm should take. The details of construction were discussed with Mr. Cranmer. Basically, those details include the removal of vegetation in the area where the berm would rest. The berm would consist mainly of quarry run rock which would have a size gradation from angular gravel sized fragments up to cobbles 4-6 inches in diameter. Some dirt and fine textured material likely will be mixed in with this material. The less of this material, the better. A foot or so thickness of finer sized sand and gravel should be placed adjacent to the dam as a seepage control layer between the earthen portion of the dam and the coarser quarry run rock portion of the gravel berm. This seepage control material could consist of creek gravel that has been left after the screening of a selected size of creek gravel. Although this type of gravel is basically rejected for many uses because it has a variety of sizes and material, it would be suitable for use in the berm between the earthen portion of the dam and the remainder of the quarry run rock used in the berm.

The extent of the gravel berm at the present time could be limited to the area where seepage has caused the most serious increase in softness of the earthen material near the downstream toe of the dam. With a suitable access road and a continued maintenance program, the berm could be enlarged or other areas also stabilized if a need might develop at a later date.

In conjunction with the construction of the berm, it is important to improve the downstream drainage of the stream channel immediately adjoining the dam. Presently, the stream channel is choked with cattails and brush and has a stagnant pool of water. This further weakens the floodplain foundation immediately adjoining the dam. Cleaning out the channel and removing obstructions downstream to a point where the stream drains freely will accomplish a great deal in improving the maintenance and therefore safety of the lower slope of the dam.

With the lake at its present low level, this is the best time to add to the riprap where it is inadequate or has been partially removed by wave erosion. Mr. Crammer is aware of the areas where such repair is needed. Given the long fetch, wave erosion will seriously damage the dam if the riprap is not kept in excellent condition.

All of the willows and popular tree vegetation should be destroyed. Cutting will remove this material but re-growth will continue. A herbicide treatment will be more effective for long term prevention of vegetation problems.

The discharge of the 36 inch principal spillway pipe has caused some serious bank erosion in the receiving stream channel. Although not of an immediate need, plans should be considered to control this discharge. Within the next year or so, the repair procedure could be the excavation of a 10 foot wide rock excavated drainage to capture the flow from the principal spillway pipe and channelize it directly into the receiving stream channel (see attached sketch #2). This rock excavated channel, therefore, would have a northwesterly trend and would keep water from flowing directly west out of the spillway and eroding the floodplain. Depth of excavation of this rock channel likely will be at least 5 feet. Rock removed from this channel should be utilized to protect the present floodplain from further serious erosion.

SUMMARY:

The contingency plans and the maintenance program includes removal of the guardrail portion across the spillway, the routine inspection of the dam and continuous repair all have contributed to an excellent lake. It is hoped that this interest continues as it certainly makes Indian Hills to be one of the better lakes in the state of Missouri.

Dr. J. Hadley Williams, Chief
Engineering Geology Section
Geology & Land Survey
October 31, 1978

cc: Walter Ernert
1126 Lakeshore Drive
Indian Hills, Star Route
Cuba, MO

RESERVOIR WORKSHEET

NAME: Indian Hills
LOCATION: Crawford County
OWNER:

1a) Surface area 326 acres

1b) Freeboard 5½ feet

1c) volume storage (Vs) 1793 acre feet

2a) inches precipitation 7.35

2b) runoff coefficient .79

2c) inches runoff 4.95

2d) drainage area 9792 acres 15.3 square miles

2e) volume runoff (Vr) 4039.2 acre feet

3) K = Vs/Vr .44

4) Beta .40

5a) Slope of watershed 31 feet/mile

5b) Peak inflow (Qi) 6,500 cfs

6) Peak outflow (Qc) 2600 cfs
Qo = B(Qi)

7) Minimum spillway width 67 feet x 5½'

8) Classification

9) Max. Height 53' crest length

10) Experienced maximum flood

11) Existing spillway capacity 5850 cfs (Emergency spillway)

12) Total reservoir storage

Emergency Spillway only for 100yr Storm

Spillway rec 150' x 5½' ⇒ 5850 cfs

Oct. 30, 1978
ET Ivany

56

ENGINEERING GEOLOGIC REPORT OF THE INDIAN HILLS DAM

CRAWFORD COUNTY, MISSOURI

LOCATION: With the dam near the north section line, of Sec. 15, on Brush Creek, T. 39 N., R. 5 W., Cuba Quadrangle.

At the request of Mr. James Palozzolo, Indian Hills Property Association, a surficial examination of the dam was made on 23 November 1977 to determine if obvious deficiencies exist that would require attention from the leakage or safety aspects of the dam. No problems were noted that would require immediate attention.

The small landslide under the left abutment (west) as mentioned by Lutzen in the April 1968 report and by Williams and Maxwell in the April 1973 report has either been satisfactorily repaired and/or no recent movement of the slide has taken place. The bulk portion of the dam appears to be in very good condition with only very minor erosion and slump conditions observed. This is normal in an earthen dam and no recommendations for corrective procedures is made. Minor seepage problems under the apron of the emergency spillway was not observed due to the low water in the lake which was being lowered on the date of this investigation.

The small seepage problems mentioned in earlier reports appear to be enlarging in that a considerable flow of water was observed below the toe of the dam near the vicinity of the original stream bed in the west (left) abutment area. No flow measurements were taken but a cumulative flow estimated to be approximately 200 gpm is present as surface flow from the floodplain area just west of the principal spillway to the left abutment. Beavers have ponded the flow below the dam to where pools exist. A good measurement of total flow would be difficult in the existing setting. It could not be determined whether the leakage is from the internal drainage system in the dam (assuming a drainage system was constructed) or whether the flow was from under the dam and through the core area of the dam at foundation level. No piping of fill material from the dam was noted. The muddy water in the pools below the dam is thought to be from activity of beaver and muskrats rather than soil material piping from the foundation of the dam. No water was observed moving through the dam on the lower or downstream slope. All water appears to be coming up from at or below the base of the structure.

The flow observed downstream of the dam should not be enough to affect the water line of the lake mainly because of the tremendous quality of water stored in the lake at full lake capacity. The quantity has increased from past observations to the point where it should be observed at least on a yearly basis. If the flows start to become muddy, then corrective procedures to seal off the leakage would be necessary to protect the integrity of the dam. To accurately measure the total amount of water loss on a yearly basis, (mainly to detect large increases of flow) a shallow ditch would have to be constructed parallel to the toe of the dam 50 or 60 feet downstream of the dam to collect the water and then the outflow from the ditch monitored with a measuring device such as a weir. Lowering of the pool levels caused by the beaver dams probably would be necessary to accomplish this.

No estimate of the spillway adequacy can be made by this office. The spillway appears to be in sound physical condition. The drainage area serving the lake is approximately 9,000 surface acres, and assuming a 300 acre lake, has a drainage to lake ratio of approximately 30 to 1. This ratio is not excessive but should be very adequate to maintain a relatively stable lake level. An engineering firm experienced in lake spillway design should be employed to calculate the adequacy of the spillway system if this information is desired by the association.

RECOMMENDATIONS:

It is recommended that the quantity of water cumulatively flowing downstream of the dam be monitored at least on a yearly basis so that large increases of flow, if they occur with time, can be noted. If the leaking water turns muddy, immediate corrective action by the use of grouting or other techniques would be necessary to seal off the larger leaks to protect the integrity of the dam.

In summary, no adverse conditions appear to exist that would affect the safety of the dam at Indian Hills.

Thomas J. Dean, Geologist
Applied Engineering & Urban Geology
Geological Land Survey
November 3, 1977

cc: James Palozzolo
Indian Hills Property Assoc.
Star Route
Cuba, MO

MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES
BUEHLER PARK ROLLA MISSOURI 65401 314-364-1752

WALLACE B HOWE STATE GEOLOGIST AND DIRECTOR

LARRY D FELLOWS ASSISTANT STATE GEOLOGIST

ADDENDUM TO LETTER REPORT OF APRIL 13, 1969
INDIAN HILLS LAKE

Crawford County, Missouri

LOCATION: Sec. 15, T. 39 N., R. 5 W., (Cuba Quadrangle)

GEOLOGIC SETTING:

Indian Hills Lake is in a region that geologically is an excellent location for water impoundment. The underlying bedrock is relatively watertight and competent. Soils on valley slopes are clay-rich and are suitable for use in an earthen dam.

RECOMMENDATIONS:

Overall the dam and lake, as observed on 12 January 1973, are in excellent shape and could serve as an example of how a dam and lake should be constructed. No failure hazards exist, but routine maintenance needs should be given consideration at this time to forestall more costly repairs.

Perhaps the item of most importance is to reduce the volume of silt being carried into the lake. The watershed drains from soils which are easily susceptible to erosion. Thus, detention basins constructed in the headwater portions of the lake would reduce flood crest peaks and do much toward limiting the silt load that collects in the upper lake reaches. Sediment detention would also improve water quality and clarity. Low water dams constructed either on the main tributary just above the lake or on a left (west) bank tributary valley (McDade Branch are suggested as a means of detaining the load of sediment washing into the lake. Several types of detention dams could be considered. For example, reinforced concrete with constant overflow spillway, gated spillway, perhaps with draw-down facilities as typical of low water dams. The spillway gates could be of heavy wooden planks. Alternate types of dams include gabbions, rectangular wire cages holding rock fragments of some 4 to 6 inches diameter. The cages

can be made of heavyduty woven wire. Such gabbion dams could be built inexpensively in the upper end of the present lake.

Other items considered during the inspection on 12 January, included the small slide first observed during a previous site inspection by Lutzen (13 April 1969). No evidence of movement or implications of hazards to the dam were observed at the time of this inspection. However, plans to monitor the slide area by establishment of surveyed bench marks are recommended to provide a procedure to precisely determine if movement is in progress. The bench marks should be outside the suspected slide area, in the lower one-third portion of the slide and in the upper one-third of the suspected slide.

Of most concern to the maintenance needs of the dam is the stability of the small berm on the west side of the primary spillway pipe outlet. Erosion is seriously affecting one segment of this berm. If left unchecked, the berm will be breached allowing water to flow westward across the floodplain near the downstream toe of the dam. An unsightly ditch will result whose appearance will magnify a hazard that is more an eyesore than a danger. Repair at this time could be easily accomplished by placing a compacted fill of stone and clay in the eroded part of the spillway. Sufficient borrow dirt, including loose rock, for this repair, exists on the eastern slope adjoining the primary spillway outlet actually just across from the eroded portion of the berm. To prevent water flow from destroying the repaired portion of the spillway berm, a dirt ledge should be removed on the upslope (eastern) side of the primary spillway ditch. The present ledge diverts water flow against the dirt levee, and has caused the partial destruction of the spillway.

Seepage under the right portion of the dam exists to a minor extent. Collection of water on the floodplain which sustain willow and cattail growth is caused by this. This swamp-like setting should be drained to reduce the wetness problems in the vicinity of the downstream toe of the dam. All trees on or near the dam should be cut.

The inspection by Lutzen noted at that time water was seeping outside the primary spillway pipe and under the concrete apron of the emergency spillway. The former problem still exists. The latter could not

e observed at the time of this inspection because the area was partially ice covered.

Lastly, the emergency spillway has been diverted by rock ledges so that an unsightly ditch has been eroded across the floodplain. The eroded ledges may be considered to be a scenic attraction. The erosion of the floodplain presents no hazard to the dam. The repair procedures would require extensive rock blasting and removal. Thus, the alternative of allowing the discharge from the emergency spillway to flow across the floodplain in its present course is perhaps the only reasonable choice at this time.

SUMMARY:

Overall the dam is in excellent condition. No immediate hazards exist. If the problem of siltation could be solved, at least partially, this would be a significant achievement. Repair of the primary spillway berm should be accomplished as soon as possible. Bench mark survey points on the suggested, but not proven, slide could be monitored once or twice yearly.

Dr. James Maxwell
Professor
Geology Department
University of Missouri-Rolla
April 11, 1973

J. Hadley Williams
Geologist and Chief
Applied Engineering & Urban Geology
Missouri Geological Survey
April 11, 1973

ADDENDUM
INDIAN HILLS LAKE

Crawford County, Missouri

LOCATION: Sec. 15, T. 39 N., R. 5 W., (Cuba Quadrangle)

GEOLOGIC SETTING:

Indian Hills Lake is in a region that geologically is an excellent location for water impoundment. The underlying bedrock is relatively watertight and competent. Soils on valley slopes are clay-rich and are suitable for use in an earthen dam.

RECOMMENDATIONS:

Overall the dam and lake, as observed on 12 January 1973, are in excellent shape and could serve as an example of how a dam and lake should be constructed. No failure hazards exist, but routine maintenance needs should be given consideration at this time to forestall more costly repairs.

Perhaps the item of most importance is to reduce the volume of silt being carried into the lake. The watershed drains from soils which are easily susceptible to erosion. Thus, detention basins constructed in the headwater portions of the lake would reduce flood crest peaks and do much toward limiting the silt load that collects in the upper lake reaches. Sediment detention would also improve water quality and clarity. Low water dams constructed either on the main tributary to the lake or on a left (west) bank tributary valley (McDade Branch) are suggested as a means to detain the load of sediment washing into the lake. Several types of detention dams could be considered. For example, reinforced concrete with constant overflow spillway, gated spillway, perhaps with withdraw down facilities as typical of low water dams. The spillway gates could be of heavy wooden planks. Alternate types of dams include gabbions, rectangular wire cages holding rock fragments of some 4 to 6 inches diameter. The cages can be made of heavy-duty woven wire.

Other items considered during the inspection on 12 January, included the small slide first observed during a previous site inspection by Lutzen (13 April 1969). No evidence of movement or implications of hazards to the dam were observed at the time of this inspection. However, plans to monitor the slide area by establishment of surveyed bench marks are excellent and will provide a procedure to precisely determine if movement is in progress. The bench marks should be outside the suspected slide area, in the lower one-third portion of the slide and in the upper one-third of the suspected slide.

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Seepage under the right portion of the dam exists to a minor extent. Collection of water on the floodplain which sustain willow and cattail growth is caused by this. This swamp-like setting should be drained to reduce the wetness problems in the vicinity of the downstream toe of the dam. All trees on or near the dam should be cut.

The inspection by Lutzen noted at that time water was seeping outside the primary spillway and under the concrete apron of the emergency spillway. The former problem still exists. The latter could not be observed at the time of this inspection since the area was partially ice covered.

Lastly, the emergency spillway has been diverted by rock ledges so that an unsightly ditch has been eroded across the floodplain. The repair procedures would require extensive rock blasting and removal. Thus, the alternative of allowing the discharge from the emergency spillway to flow across the floodplain in its present course is perhaps the only reasonable choice at this time.

SUMMARY:

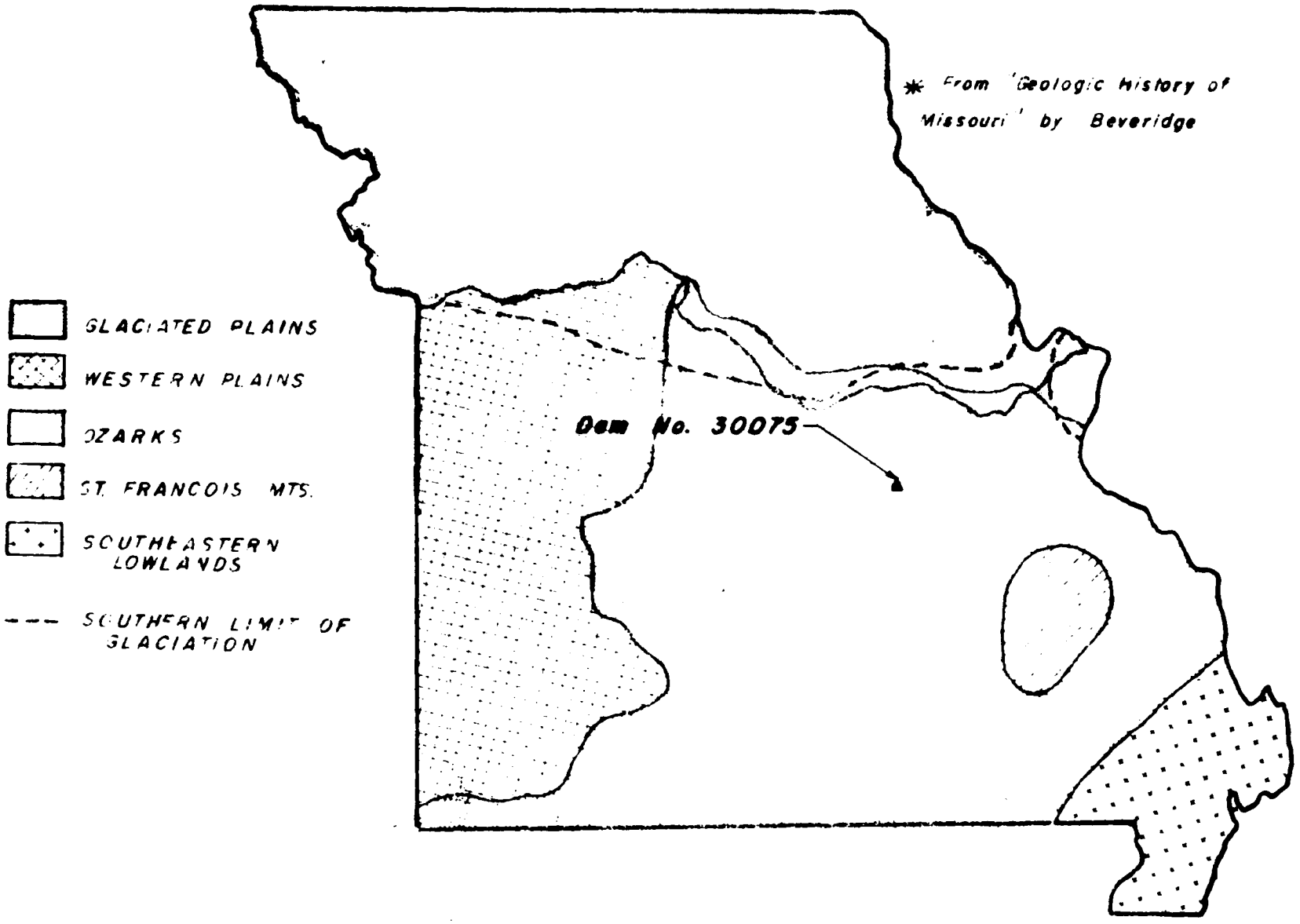
Overall the dam is in excellent condition. No immediate hazards exist. If the problem of siltation could be solved, at least partially, this would be a significant achievement. Repair of the primary spillway berm should be accomplished as soon as possible. Bench mark survey points on the suggested, but not proven, slide could be monitored once or twice yearly.

Dr. James Maxwell, Professor
Geology Department
University of Missouri-Rolla
March 9, 1973

J. Hadley Williams, Chief
Applied Engineering & Urban Geology Section
Missouri Geological Survey
March 9, 1973

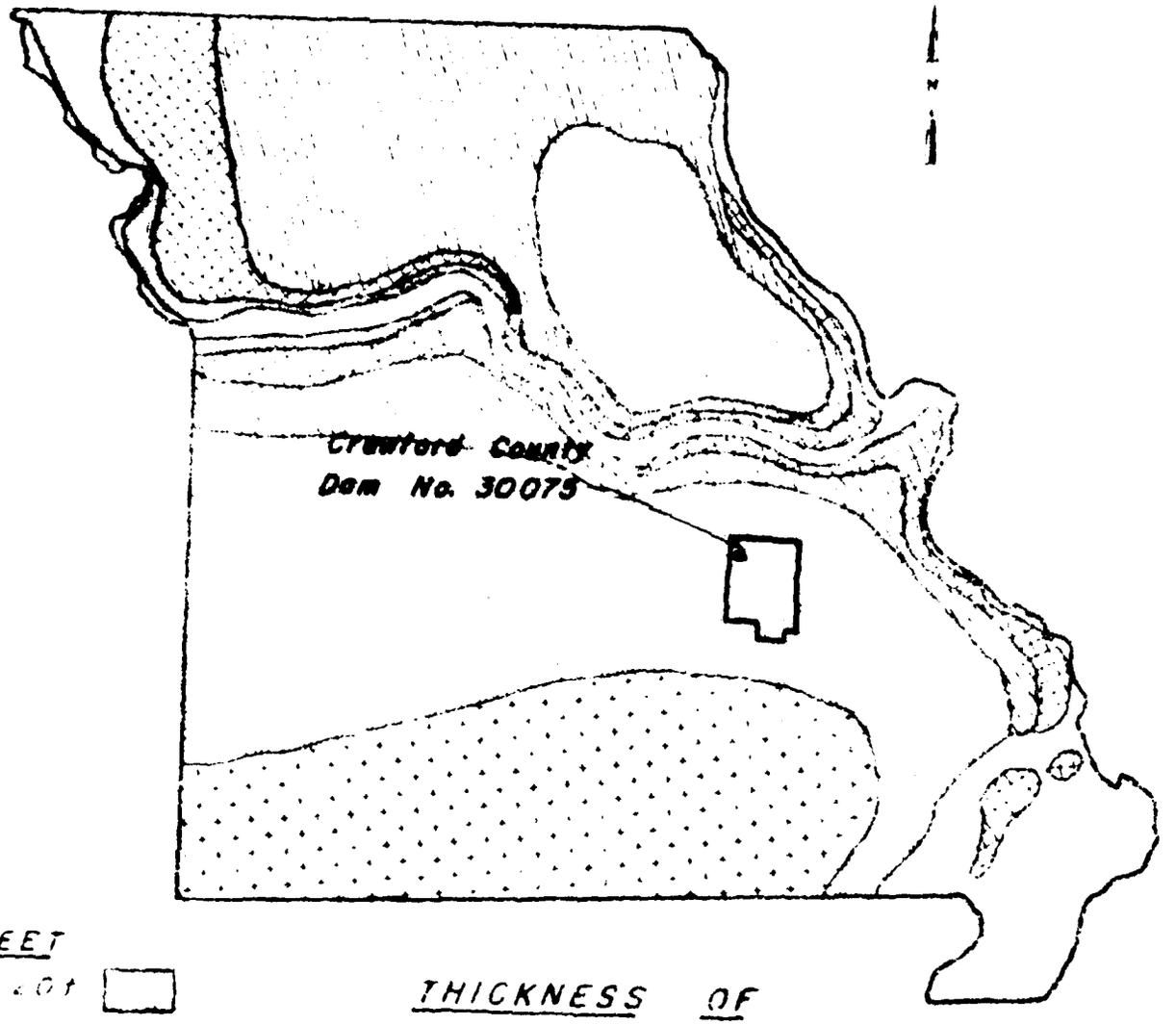
APPENDIX B

MAJOR GEOLOGIC REGIONS OF MISSOURI



SHEET 1 OF APPENDIX B

From "Soils of Missouri"



FEET

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10-20 ▭

5-10 ▭

2.5-5 ▭

2.5- ▭

THICKNESS OF LOESSIAL DEPOSITS

APPENDIX C

HYDRAULICS AND HYDROLOGIC DATA

Design Data: From Field Measurements and Computations

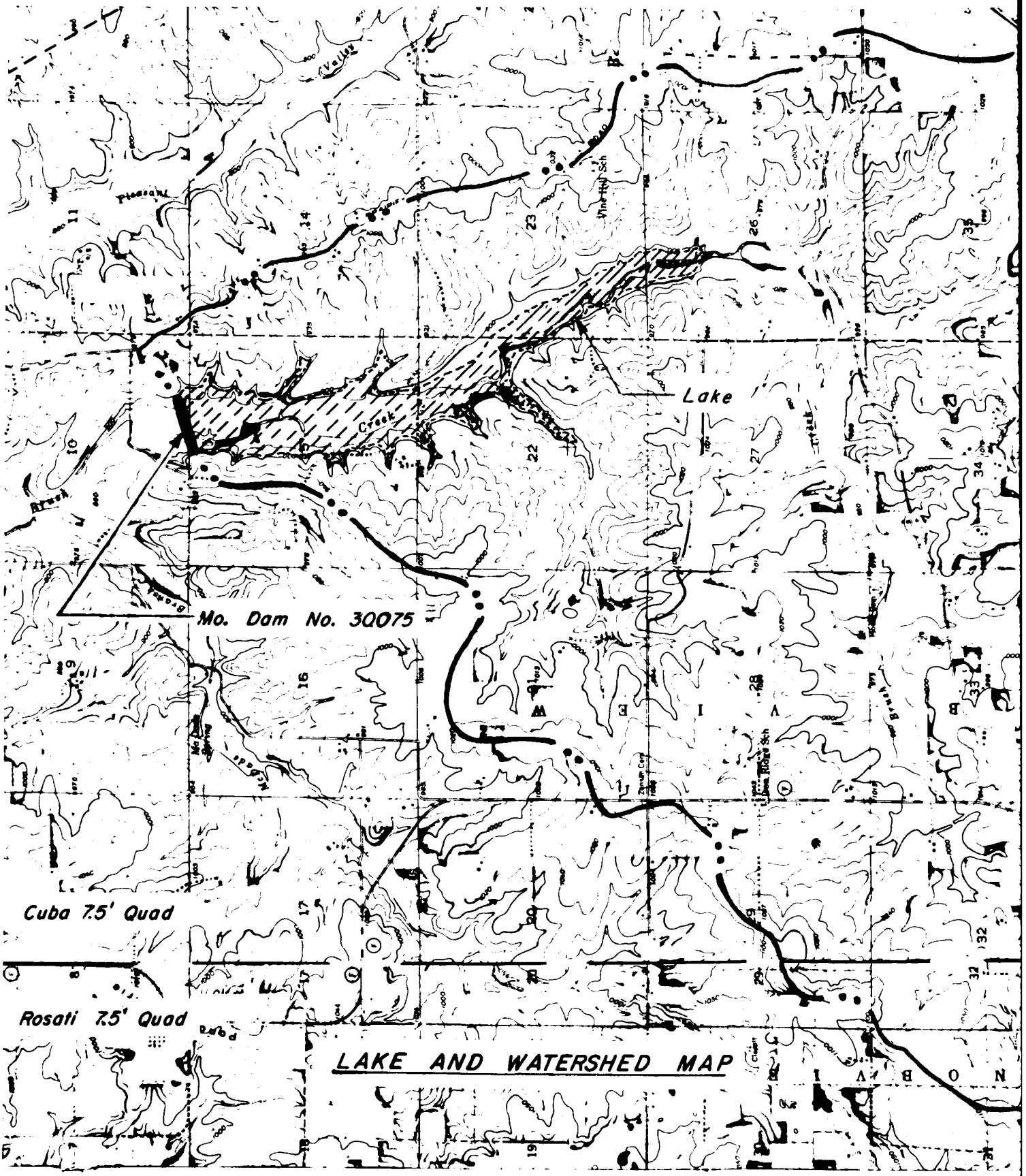
Experience Data: No records are available. The day of inspection there was no indication that the dam has been overtopped. High water marks were found at elevation 898.8. The heavy erosion of the primary and emergency spillways outlet channels indicates that both spillways have been used very frequently.

Visual Inspection: At the time of inspection, the pool level was approximately 0.24 below normal pool.

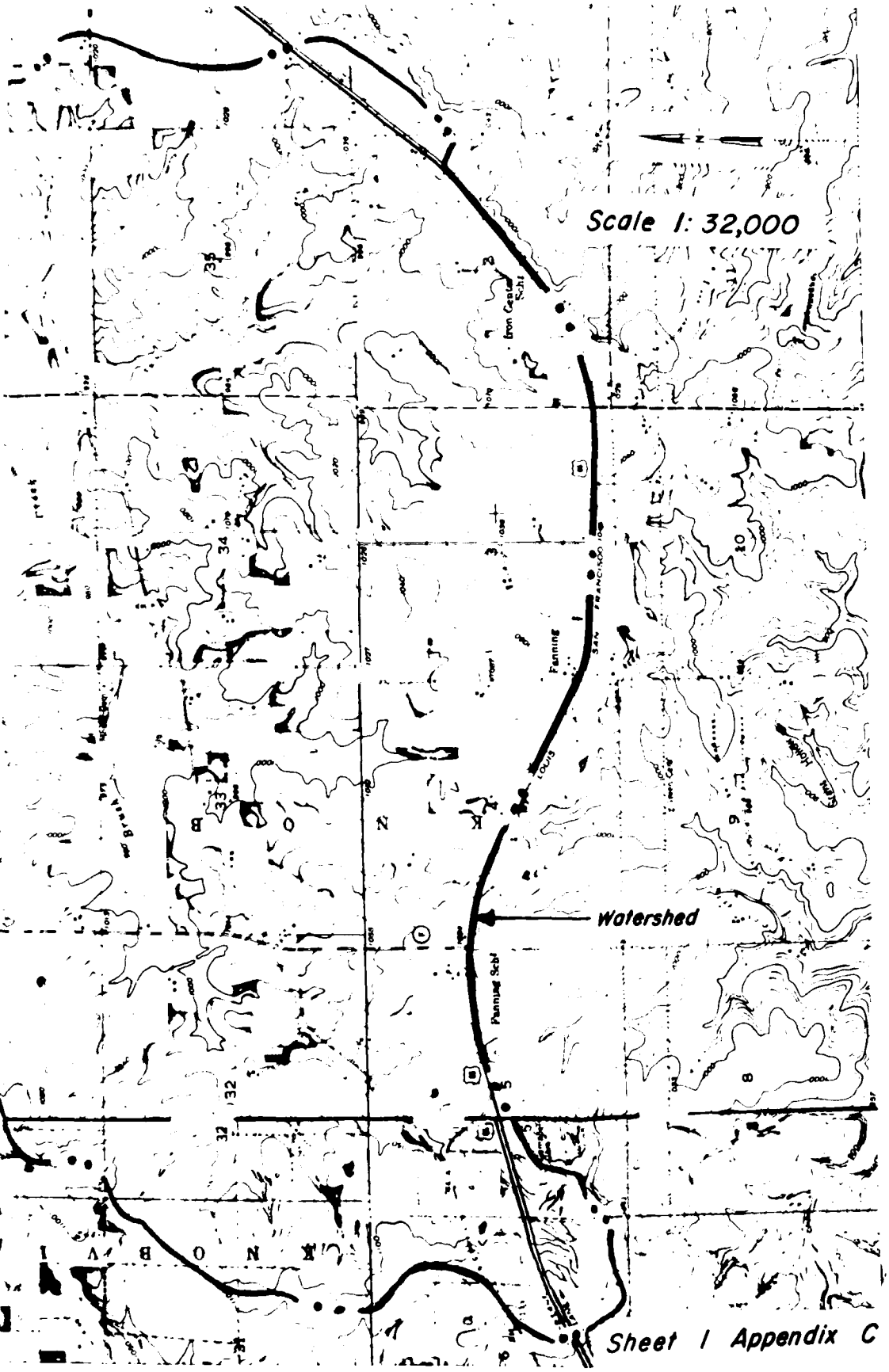
Overtopping Potential: Flood routings were performed to determine the overtopping potential. The watershed and the reservoir surface areas were obtained by planimeter from the U.S.G.S. Cuba and Rosati, Missouri 7.5 minute quadrangle maps. The storage volume was developed from this data. A 5 minute interval unit graph was developed for the watershed, which resulted in a peak inflow of 5131 c.f.s. and a time to peak of 72 minutes. Application of the probable maximum precipitation, minus losses resulted in a flood hydrograph peak inflow of 73,621 c.f.s. Rainfall distribution for the 24 hour storm was according to EM 1110-2-1411.

Based on our analyses, the combined spillways will pass 15 percent of the Probable Maximum Flood (PMF). The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that the structure (intermediate size with high downstream hazard potential) pass the PMF, without overtopping.

The routing of the PMF through the spillways and dam indicates that the dam will be overtopped by 5.17 ft. at elevation 905.17. The duration of the overtopping will be 8.50 hours, and the maximum outflow will be 68,300 c.f.s. The maximum discharge capacity of the combined spillways is 6331 cfs. The routing of the 100-year frequency flood indicates that this event will not overtop the dam. The computer input, output and hydrographs for the PMF are presented on the following sheets of this Appendix C.



LAKE AND WATERSHED MAP


Scale 1: 32,000
Watershed
Iron Canal Sch.
Fanning
Fanning Sch.
Sheet 1 Appendix C

OVERTOPPING ANALYSIS FOR INDIAN HILLS DAM

INPUT PARAMETERS

1. Unit Hydrograph - SCS Dimensionless - Flood Hydrograph Package (HEC-1); Dam Safety Version Was Used.
   Hydraulic Inputs Are as Follows:

   a. Twenty-four Hour Rainfall of 25.8 Inches for 200 Square Miles - All Season Envelope

   b. Drainage Area = 9714 Acres; = 15.2 Square Miles

   c. Travel Time of Runoff 1.93 Hrs.; Lag Time 1.16 Hrs.

   d. Soil Conservation Service Soil Group D

   e. Soil Conservation Service Runoff Curve No. 90 (AMC III)

   f. Proportion of Drainage Basin Impervious 0.05

2. Spillways

   a. Primary Spillway: Drop inlet structure (4.5 ft. x 4.5 ft.) and 36 in. I.D. outlet pipe (CMP)

   b. Emergency Spillway: Trapezoidal broad crested concrete Weir.
   Length 152 ft.; Side Slopes Vary; C = Varies

   c. Dam Overflow

   Length 1300 ft.; Crest El. 900.0; C = 3.0

3. Spillway and Dam Rating:

   Curve Prepared by Hanson Engineers. Data Provided to Computer on Y4 and Y5 Cards.

   Formula Used:
   Primary Spillway: Weir Control $Q=CLH^{1.5}$
   Pipe Control U.S. Bureau, Public Roads Chart 288-D-2909

   Emergency Spillway: $\frac{Q^2}{g} = \frac{A^3}{T}$

Note: Time of Concentration From Equation $Tc = \frac{(11.9\ L^3)^{.385}}{(H)^{.385}}$

California Culvert Practice, California Highways and Public Works, September, 1942.

SUMMARY OF DAM SAFETY ANALYSIS

1. Unit Hydrograph

   a. Peak - 6131 c.f.s.

   b. Time to Peak 72 Min.

2. Flood Routings Were Computed by the Modified Puls Method

   a. Peak Inflow

      50% PMF 36,810 c.f.s.; 100% PMF 73,621 c.f.s.

   b. Peak Elevation

      50% PMF 902.84; 100% PMF 905.17

   c. Portion of PMF That Will Reach Top of Dam

      16%; Top of Dam Elev. 900.0 ft.

Computer Input and Output Data are shown on the following sheets of this Appendix.

```
A       OVERTOPPING ANALYSIS FOR INDIAN HILLS DAM (# 17)
A       STATE ID NO. 30075  CO. NO. 055  CO. NAME CRAWFORD
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 79511
B    300                5
B1     5
J      1        8        1
J1   .15      .20      .25      .30      .40      .50      .75      1.0
K      0        1                                  3        1
K1       INFLOW HYDROGRAPH COMPUTATION **
M      1        2     15.2               15.2        1                        1
P      0     25.8      102      120      130
T                                                            -1      -90              0.05
W2  1.93     1.16
X      0     -.1        2
K      1        2                            0        4        1
K1       RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                    1        1
Y1     1                                                   5301       -1
Y4 894.8    895.1    896.3    897.3    898.3    900.0    901.3    902.3    903.3    905.3
Y5     0        8      690     1696     3124     6331     9534    13436    15639    22845
$A     0      355    422.4      516
$E   850    894.8    900.0    905.0
$$ 894.8
$D   900      3.0      1.5     1300
K     99
```

P.M.F. INPUT DATA

Sheet 5 Appendix C

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

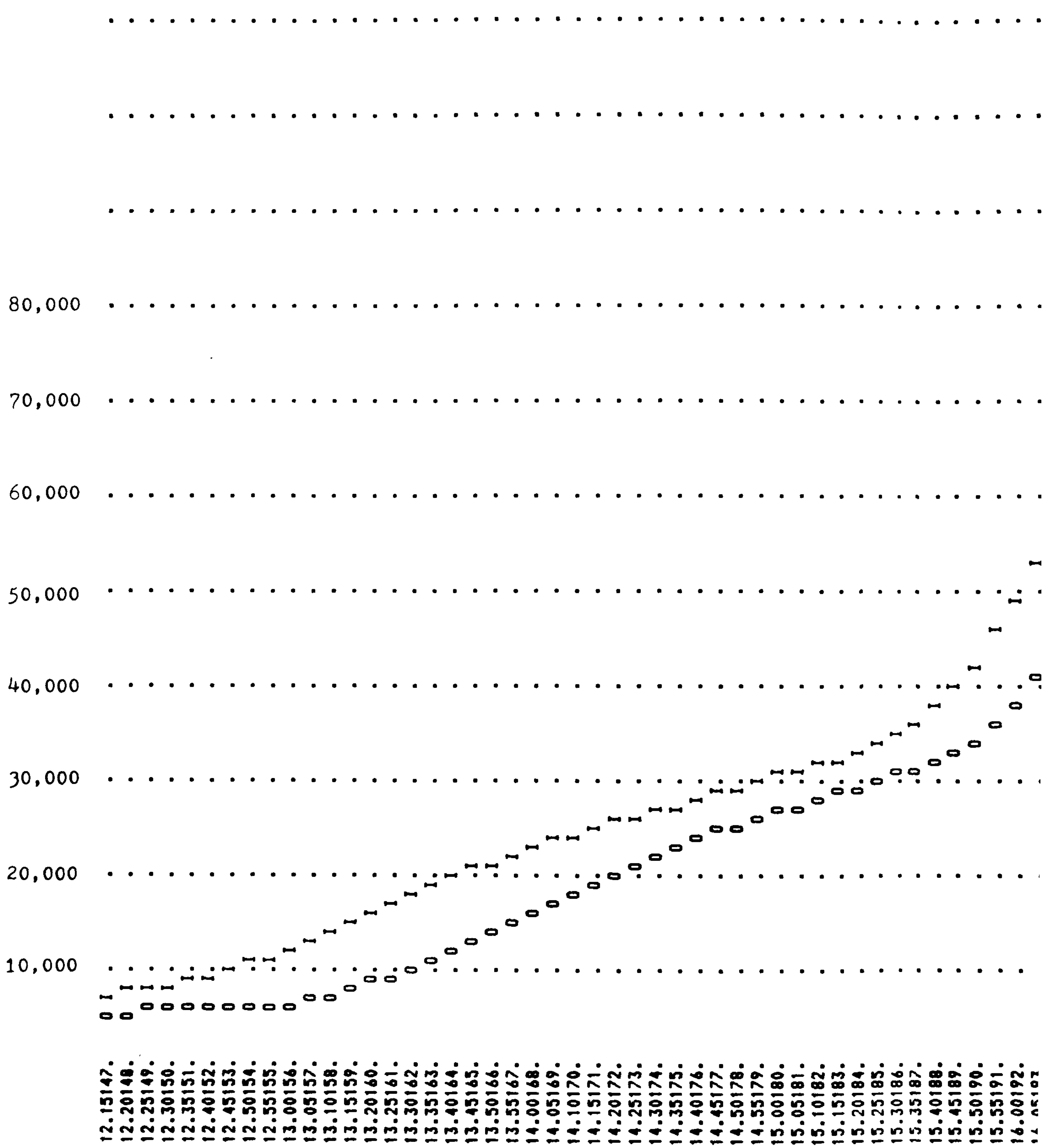
OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 0.15	RATIO 2 0.20	RATIO 3 0.25	RATIO 4 0.30	RATIO 5 0.40	RATIO 6 0.50	RATIO 7 0.75	RATIO 8 1.00
HYDROGRAPH AT	1	15.20	1	11043.	14724.	18405.	22086.	29448.	36810.	55216.	73621.
	(	39.37)	(	312.71)(	416.94)(	521.18)(	625.41)(	833.88)(	1042.35)(	1563.53)(	2084.71)
ROUTED TO	2	15.20	1	5889.	9824.	14240.	18614.	26435.	33256.	50933.	68300.
	(	39.37)	(	166.75)(	278.18)(	403.24)(	527.10)(	748.54)(	941.69)(	1442.25)(	1934.04)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	894.80	894.80	900.00
STORAGE	5300.	5301.	7320.
OUTFLOW	0.	0.	6331.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.15	899.77	0.00	7221.	5889.	0.00	18.25	0.00
0.20	900.63	0.63	7589.	9824.	2.58	17.75	0.00
0.25	901.18	1.18	7831.	14240.	3.50	17.42	0.00
0.30	901.60	1.60	8020.	18614.	4.08	17.33	0.00
0.40	902.25	2.25	8317.	26435.	5.25	17.17	0.00
0.50	902.84	2.84	8591.	33256.	6.08	17.17	0.00
0.75	904.06	4.06	9188.	50933.	7.42	17.08	0.00
1.00	905.17	5.17	9751.	68300.	8.50	17.08	0.00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15.40188.
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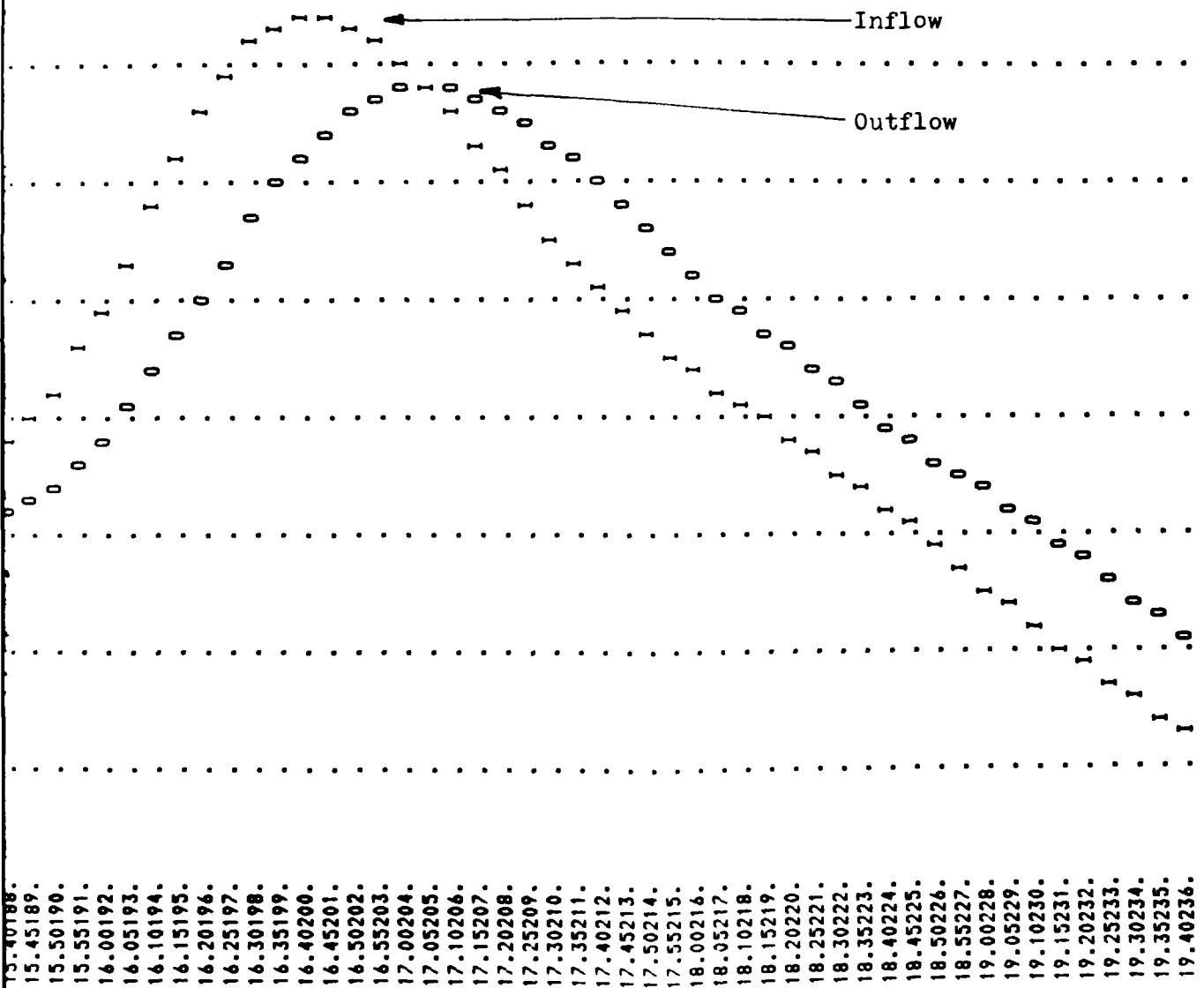
15.50190.
15.55191.
16.00192.

INFLOW - OUTFLOW

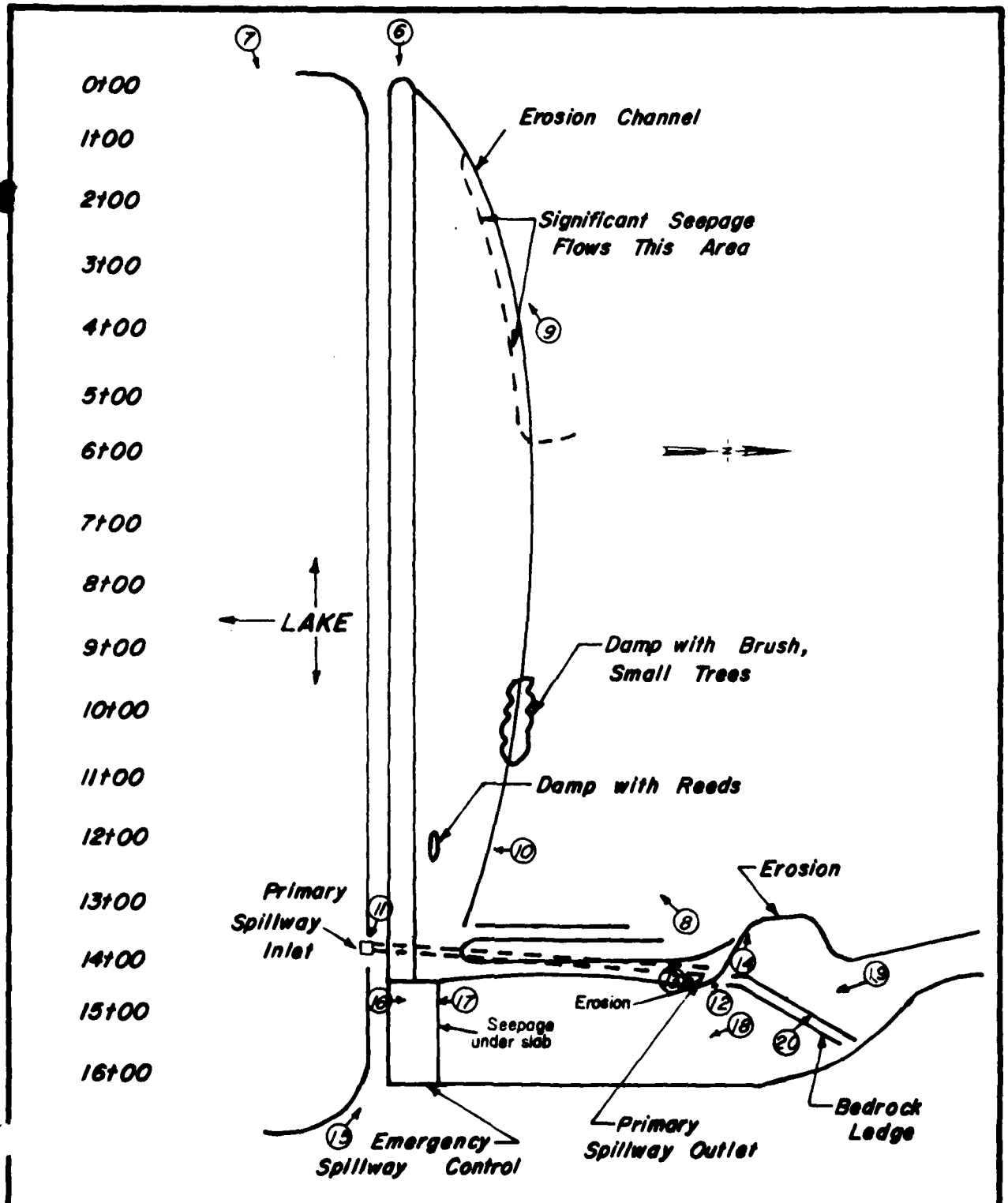
HYDROGRAPH
FOR THE P.M.F.

Max. Inflow = 73,621 c.f.s.

Max. Outflow = 68,300 c.f.s.



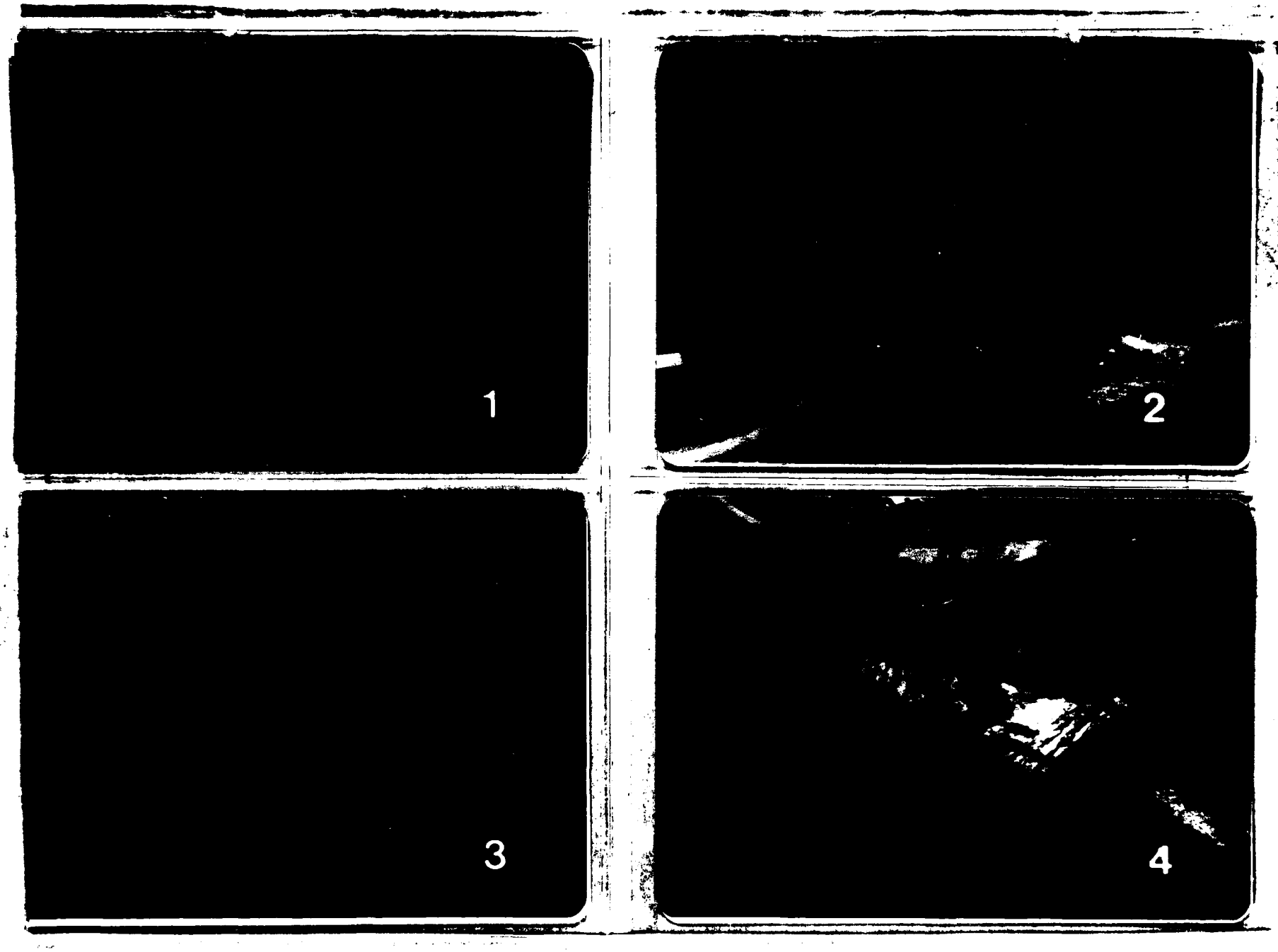
APPENDIX D



DRAWN DER CHECKED DED DATE 7-23-79 JOB NO 79511	HANSON ENGINEERS SPRINGFIELD ILL PEORIA ILL	Plan Sketch Key To Photographs Sheet 1 Appendix D

INDEX OF PHOTOGRAPHS

Photo No.	
1.	Aerial - Looking South at Lake and Watershed
2.	Aerial - Looking East at Dam, Emergency Spillway in Foreground
3.	Aerial - Downstream Face of Dam at West End, Note Ponded Water Beyond Toe
4.	Aerial - Primary and Emergency Spillways at East Abutment (Primary Spillway Flowing) - Note Erosion West of Primary
5.	Aerial- East Abutment Area & Spillway Channel
6.	Crest of Dam - Looking East
7.	Upstream Face of Dam - Looking Northeast
8.	Downstream Face of Dam - Looking Southeast
9.	Seepage Water at Downstream Toe Near West Abutment
10.	Downstream Face of Dam Between Stations 12+00 and 12+60 - Note Reeds
11.	Primary Spillway Inlet
12.	Outlet, Primary Spillway
13.	Outlet Area, Primary Spillway - Looking Downstream
14.	Erosion Banks Just West of Primary Spillway
15.	Emergency Spillway Control Section - Looking Downstream from East Side
16.	Emergency Spillway Control Section - Looking Downstream from West Side
17.	Emergency Spillway Slab - Note Undermining
18.	Emergency Spillway - Looking Upstream
19.	Emergency Spillway - Looking Upstream
20.	Emergency Spillway - Looking Downstream
21.	Aerial - Looking Southeast at Dam, Showing Grading Work Done After Field Inspection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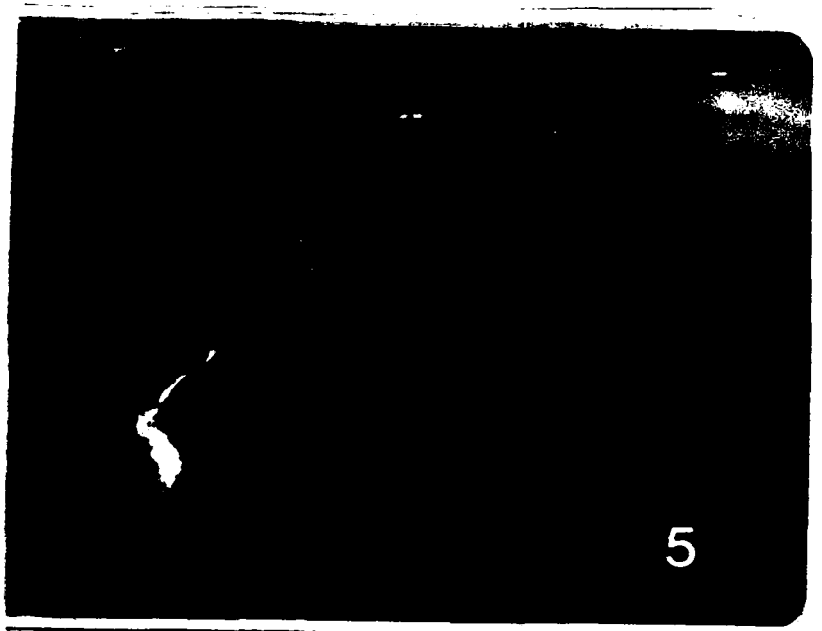
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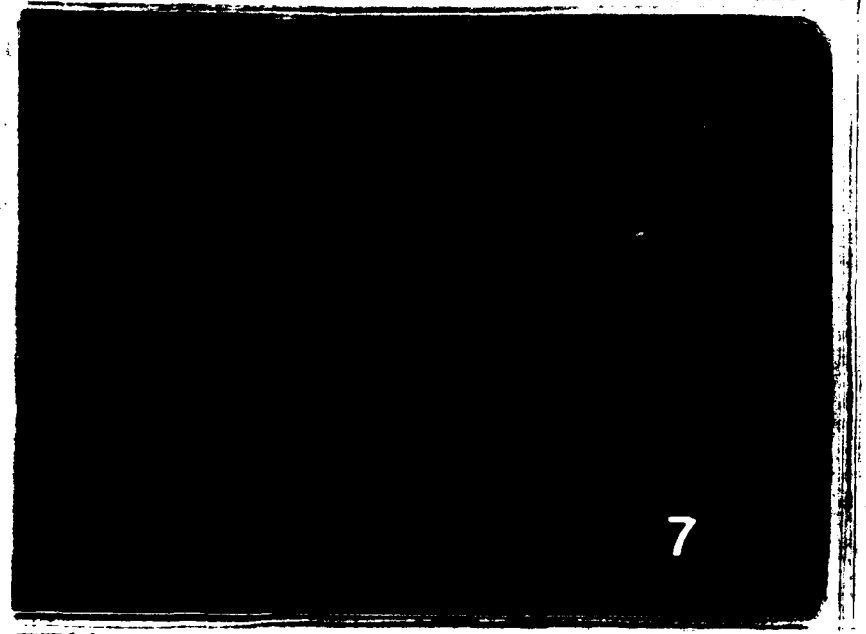
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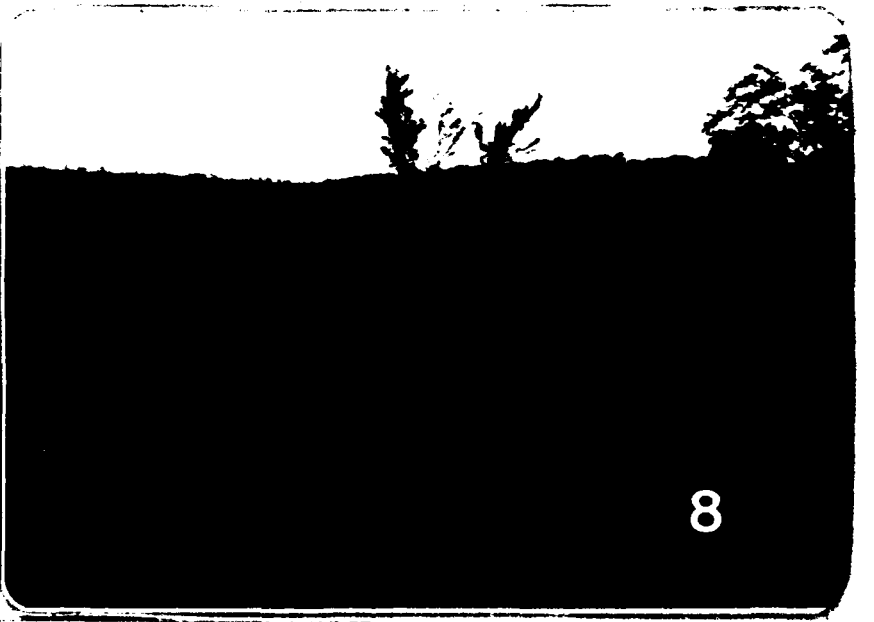
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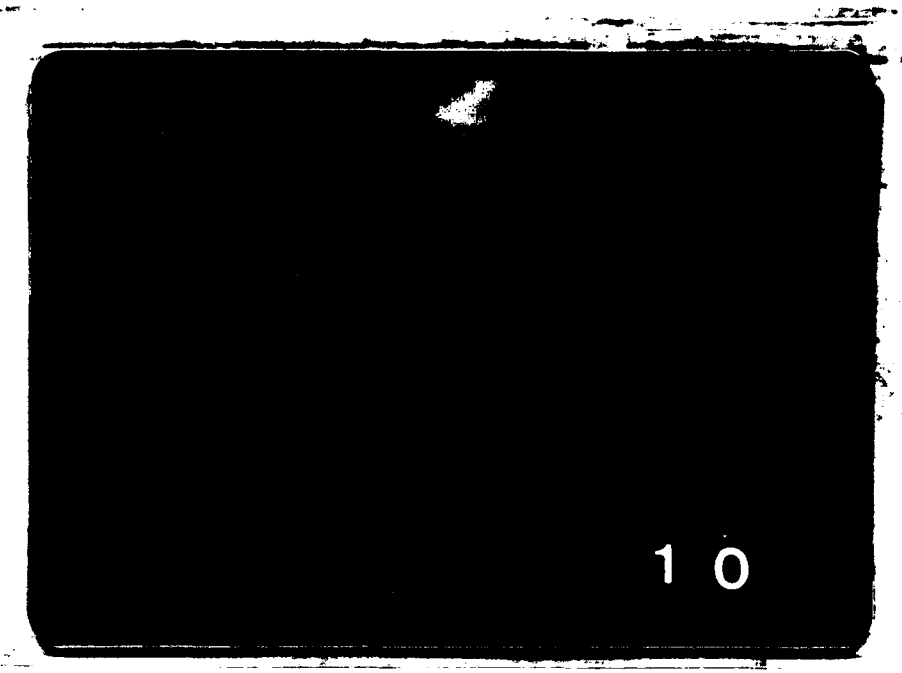
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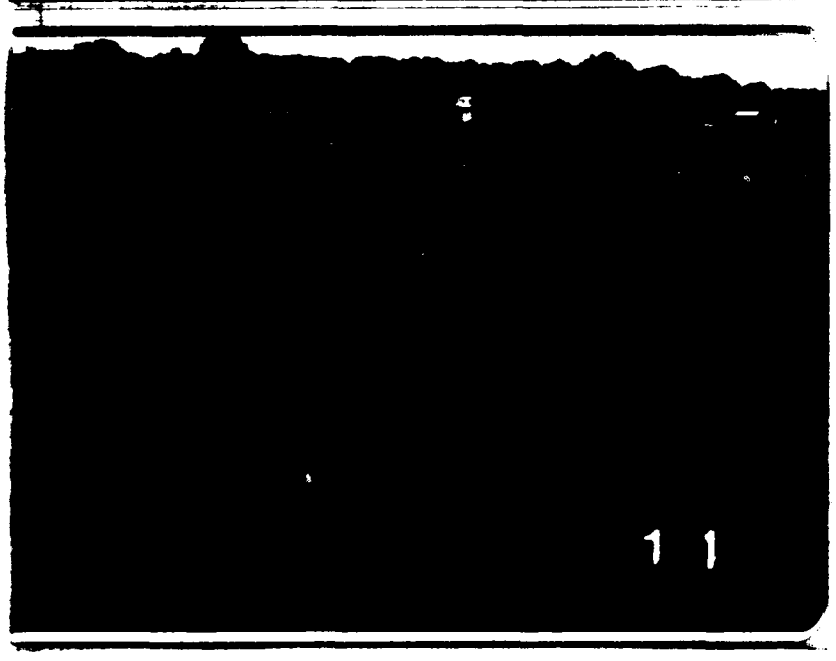
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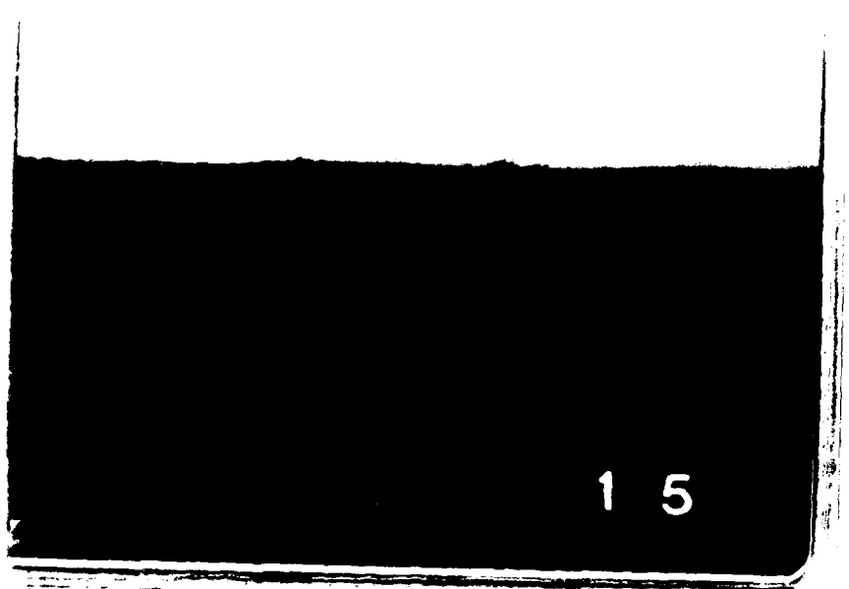
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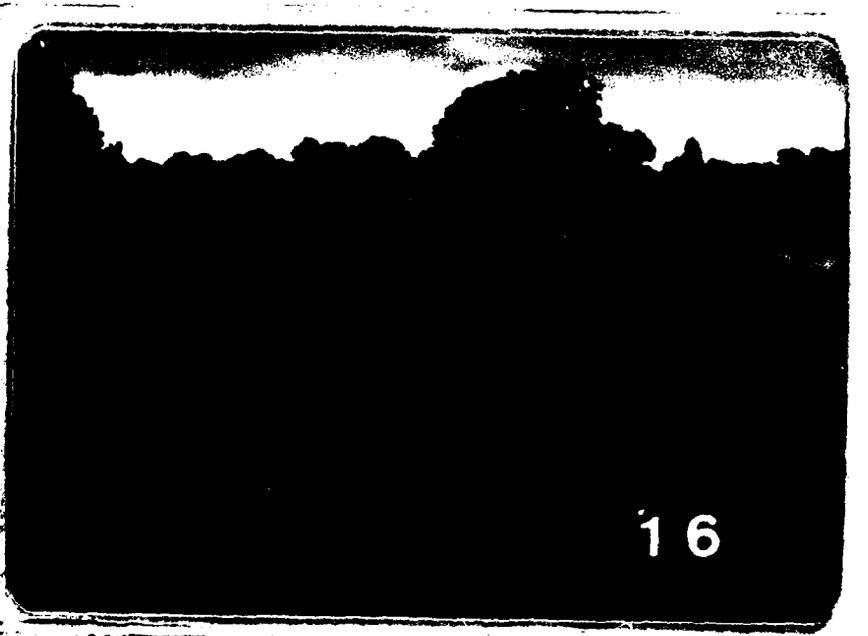
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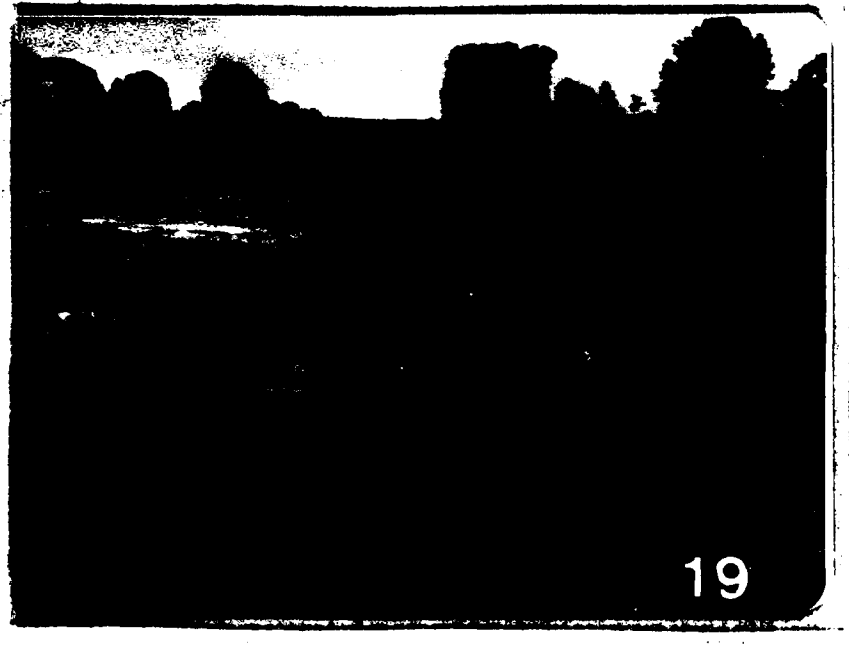
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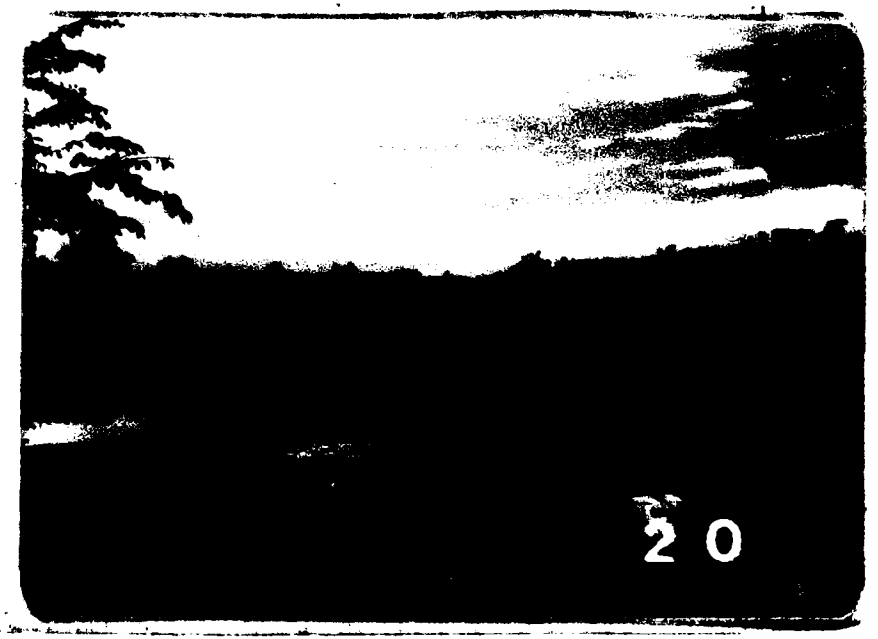
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